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ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with the basic concepts of the water world. Included are objectives, instructor guides, student handouts and transparency masters. The module considers natural cycles, natural relationships, pollution and the effect of man in these natural occurrances. (Author/RH)

NATURAL SYSTEMS

Training Module 1.310.1.77

Prepared for the

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by

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September, 1977

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SUMMARY

Module No:	Module Title: Natural Systems
	Submodules:
Approx. Time: 26 Hours	1. Primitive States of Nature 2. Aquatic Ecology 3. Water Pollution

Objectives:

Upon completion of this module the participant should be able to:

1. Describe the natural cycles of nature and natural fresh water supplies including lakes, streams, and ground water.
2. Identify natural relationships and the effect of man.
3. Identify pollutants, describe effects of pollution and examine corrective measures which may be taken to control water pollution.

Instructional Aids:

Handouts # 1, 2, 3, 4
Transparancies # 1 - 25

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, D. Van Nostrand Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Warren, Charles E., Biology and Water Pollution Control, W. B. Saunders Co., Philadelphia, Pa., 1971.
4. Water Resources of Iowa, 1970.
5. Sarai, Darshan, Ecology & Stream Purification, Water & Wastewater Technological School, Neosho, Missouri.
6. Chanlett, Emil, Environmental Protection, McGraw Hill, New York, 1973.
7. Lundquist, John B., A Primer on Limnology, Number 1, March 1975, Water Resources Research Center, University of Minnesota.
8. Walton, Groundwater Resource Evaluation, McGraw Hill, New York, 1970.
9. ______, Groundwater and Wells, Johnson Division UOP, St. Paul, Minnesota, 1972.

Class Assignments:

Read Handouts
Work assigned problems

Module No:	Topic: SUMMARY

Instructor Notes:	Instructor Outline:
Handout # 1 Transparancies # 1 - 6	1. Discuss and illustrate the physical properties of water and the hydrologic cycle. 2. Discuss and diagram: a. A typical food chain b. Nitrogen cycle c. Oxygen cycle d. Carbon cycle e. Sulfur cycle 3. Give and work problems relating cycles to food chain.
Handout # 2 Transparancies # 7 - 12	4. Discuss and illustrate natural fresh water supplies including lakes, streams, and ground water.
Handout # 3 Transparancies #13	5. Discuss aquatic ecology with respect to interrelationships of natural populations and the effect man has had on the natural balance.
Handout # 4 Transparancies # 14 - 25	6. Discuss pollution with respect to history, types, sources effect and corrective measures.

Module No:	Module Title: Natural Systems
	Submodule Title: Primitive States of Nature
Approx. Time: 1 hour	Topic: Chemical/Physical Properties of Water

Objectives:

Upon completion of this module, the participant should be able to:

1. Illustrate the water molecule.
2. Describe to the instructor's satisfaction, the physical properties of water to include:

   a. Specific heat
   b. Density
   c. Solvent action
   d. Surface tension and cohesion

Instructional Aids:

Handout # 1
Transparancy # 1

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, D. Van Nostrand Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Warren, Charles E., Biology & Water Pollution Control, W. B. Saunders Co., Philadelphia, Pa., 1971.

Class Assignments:

Read Handout # 1

Module No:	Topic: Chemical/Physical Properties of Water
Instructor Notes:	**Instructor Outline:**
Transparency # 1 Handout # 1 1. Emphasize 1. Structure 2. Bonding using transparancies	1. Illustrate and discuss the structure or the water molecule.
2. Emphasize concepts rather than numbers. Then relate concepts to living systems.	2. Discuss the physical properties of water including, a. Specific heat b. Solvent action c. Densities d. Surface tension and cohesion

Module No:	Module Title: Natural Systems
	Submodule Title: Primitive States of Nature
Approx. Time: 3 hours	Topic: Natural Cycles

Objectives:

Upon completion of this module, the participant should be able to:

1. Illustrate the hydrological cycle.
2. Describe a typical food chain, limiting factors, and energy flow dependent on surface water.
3. Demonstrate the relationship of:
   a. Bacteria and plants in the nitrogen cycle.
   b. Plants and animals in the oxygen cycle.
4. Illustrate:
   a. The carbon cycle.
   b. The sulfur cycle.

Instructional Aids:

Handout # 1
Transparancies # 2, 3, 4, 5, 6.

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, D. Van Nostrand Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Warren, Charles E., Biology & Water Pollution Control, W. B. Saunders Co., Philadelphia, Pa., 1971.

Class Assignments:

Read Handout # 1
Work given problem.

Module No:	Topic: Natural Cycles

Instructor Notes:	Instructor Outline:
Handout # 1 Transparancies # 2, 3, 4, 5, 6	1. Illustrate and discuss hydrological cycle using the terms: a. Precipitation b. Water shed c. Percolation d. Transpiration e. Evaporation
	2. Define food chain and diagram typical food chains with discussion of Limiting Factors and Energy Flow.
Emphasize relationships.	3. Diagram and discuss the: a. Nitrogen cycle b. Oxygen cycle
	4. Diagram and explain the: a. Carbon cycle b. Sulfur cycle
	5. Give and work a problem relating the five cycles discussed and the food chain.

Module No:	Module Title: Natural Systems
	Submodule Title: Primitive States of Nature
Approx. Time: 1 hour	Topic: Natural Waters

Objectives:

Upon completion of this module, the participant should be able to:

1. Define the meaning of natural water.
2. Relate solar radiation to color and turbidity.
3. Describe:
   a. The function of dissolved gasses in natural waters.
   b. Dissolved solids.

Instructional Aids:

Handout # 2

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, D. Van Nostrand Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Lundquist, John B., A Primer on Limnology, Number 1, ~~March~~ 1975, Water Resources Research Center, University of Minnesota.

Class Assignments:

Read Handout # 2

Module No:	Topic: Natural Waters
Instructor Notes:	**Instructor Outline:**
Handout # 2.	1. Define natural waters. 2. Discuss solar radiation and describe how it affects: a. Color b. Turbidity c. Temperature in natural waters
Emphasize: a. Oxygen b. Carbon dioxide Mention other gasses.	3. Discuss the function of the various gasses dissolved in natural waters including a discussion of: a. Oxidation-Reduction Potential b. Chemical buffering capacity c. pH 4. Describe dissolved solids and group into 3 groups: a. Total dissolved solids b. Other solids in solution c. Organics

Module No:	Module Title: Natural Systems
	Submodule Title: Primitive States of Nature
Approx. Time: 1 hour	Topic: Lakes

Objectives:

Upon completion of this module, the participant should be able to:

1. Diagram the annual temperature cycle of a natural lake.
2. List 5 non-periodic and 2 periodic movements in lakes.
3. Explain the importance of dissolved oxygen and carbon dioxide in lakes.
4. Classify lakes.

Instructional Aids:

Handout # 2

Transparancy #7

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, D. Van Nostrand Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Lundquist, John B., A Primer on Limnology, Number 1, March 1975, Water Resources Research Center, University of Minnesota.

Class Assignments:

Read Handout # 2
Work given problem.

Module No:	Topic: Lakes
Instructor Notes:	**Instructor Outline:**
Handout #2 Transparancy #7 Relate cycle to: a. Seasons b. Circulation c. Stratification d. Heat budgets e. Temperature classifications f. Zonation	1. Diagram and describe the annual temperature cycle of a lake.
Periodic movement includes discussion of: a. Wind streaks b. Density c. Laminar d. Eddy effects Non-periodic movement includes discussion of: a. Surface waves b. Seiches	2. Discuss movement in lakes using periodic and non-periodic movement classifications.

Module No:	Module Title: Natural Systems
	Submodule Title: Primitive States of Nature
Approx. Time: 1 hour	Topic: Streams

Objectives:

Upon completion of this module, the participant should be able to:

1. Relate stream size and movement to natural temperature variation.
2. Explain the importance of dissolved oxygen and carbon dioxide in streams.
3. Illustrate the relationship of origin and morphology of streams.

Instructional Aids:

Handout # 2

Transparancy #7 & 8

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, K. Van Nostrand Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Lundquist, John B., A Primer on Limnology, Number 1, March 1975, Water Resources Research Center, University of Minnesota.

Class Assignments:

Read Handout # 2
Work given problems.

Module No:	Topic: Streams

Instructor Notes:	Instructor Outline:
Handout # 2	
Transparancy #7	1. Discuss and illustrate how streams size and movement is related to its natural temperature variation.
	2. Discuss dissolved oxygen and carbon dioxide in streams with respect to quality of life in streams.
	3. Discuss and illustrate how origin determines morphology of the stream.
4. Transparancy #8	4. Give a problem where the learner will predict outcome given levels of dissolved oxygen in a given stream.

Module No:	Module Title: Natural Systems
	Submodule Title: Primitive States of Nature
Approx. Time: 1 hour	Topic: Ground Water

Objectives:

Upon completion of this module, the participant should be able to:

1. Identify artisian and water table water bearing formations.
2. Describe the basic properties of water bearing formations.

Instructional Aids:

Handout # 2

Instructional Approach:

Lecture
Discussion

References:

1. Walton, Groundwater Resource Evaluation, McGraw Hill, New York, 1970.
2. ________, Ground Water and Wells, Johnson Division UOP, St. Paul, Minnesota, 1972.

Class Assignments:

Read Handout # 2
Work given problems.

Module No:	Topic: Ground Water

Instructor Notes:	Instructor Outline:
Handout # 2	1. Discuss and diagram a. Artisian Aquifers 1. Structure 2. Flowing 3. Non-flowing 2. Discuss properties of: a. Limestone formation b. Sand and gravel formations

Module No:	Module Title: Natural Systems
	Submodule Title: Aquatic Ecology
Approx. Time: 2 hours	Topic: Natural Populations

Objectives:

Upon completion of this module, the participant should be able to:

1. Relate birth rate and life span to natural population growth.
2. Explain how several populations can form a community.
3. List a form of biological interdependence.
4. Identify methods of communication
   a. Within a population
   b. Between populations

Instructional Aids:

Handout # 3

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, D. Van Nostrand Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Warren, Charles E., Biology & Water Pollution Control, W. B. Saunders Co., Philadelphia, Pa., 1971.

Class Assignments:

Read Handout # 3

Module No:	Topic: Natural Populations

Instructor Notes:	Instructor Outline:
Handout # 3	1. Discuss growth and regulation of a population in terms of: a. Birth rate b. Food supply c. Preditors and disease d. Life span e. Distribution 2. Explain the movement of several populations towards becoming a community. 3. Discuss interactions of populations within a community in terms of: a. Sumbiosis - commercialism b. Nichis c. Competition d. Dominance e. Saprophitism f. Parasitism 4. Discuss communication with examples of communication within a population and between populations.

Module No:	Module Title: Natural Systems
	Submodule Title: Aquatic Ecology
Approx. Time: 2 hours	Topic: Natural Communities

Objectives:

Upon completion of this module, the participant should be able to:

1. Explain how two communities are dominated or co-dominated by selected populations.
2. Define what is meant by community succession.
3. Provide an example of how environmental changes upset succession pattern(s).

Instructional Aids:

Handouts # 3

Transparancies #9, 10, & 11

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, D. Van Nostrand Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Warren, Charles E., Biology & Water Pollution Control, W. B. Saunders Co., Philadelphia, Pa., 1971.

Class Assignments:

Read Handout # 4
Work given problem

Module No:	Topic: Natural Communities
Instructor Notes:	**Instructor Outline:**
Handout # 3 Transparancies #9, 10, & 11 Emphasize: 1. Normal patterns 2. Upset patterns	1. Discuss, with examples, dominance and co-dominance. 2. Discuss and diagram several succession patterns. 3. Give learner an example of a community history and have him identify: 1. Components 2. Co-dominance and dominance 3. Succession pattern

Module No:	Module Title: Natural Systems
	Submodule Title: Aquatic Ecology
Approx. Time: 2 hours	Topic: Balance within an Eco-system

Objectives:

Upon completion of this module, the participant should be able to compare and contrast balance and imbalance in an Eco-system using examples of:

a. Food supply
b. Seasonal changes
c. Population diversity
d. Birth rate and life span

Instructional Aids:

Handout # 3

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, D. Van Nostrand Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Warren, Charles E., Biology & Water Pollution Control, W. B. Saunders Co., Philadelphia, Pa., 1971.

Class Assignments:

Read Handout # 3

Module No:	Topic: Balance Within an Eco-system
Instructor Notes:	**Instructor Outline:**
Handout # 3 In discussion of natural regulation include examples of: 1. Food supply 2. Seasonal changes 3. Population diversity 4. Birth rate 5. Life span and preditors	1. Discuss balance in an Eco-system with emphasis on natural regulation.

Module No:	Module Title: Natural Systems
	Submodule Title: Aquatic Ecology
Approx. Time: 2 hours	Topic: Effect of Man

Objectives:

Upon completion of this module, the participant should be able to:

1. Give examples of how man can exist as a positive force in natural regulation.
2. Describe the role man has played in disrupting natural regulation without causing a detrimental effect on the community.

Instructional Aids:

Handouts # 3

Transparancies #12 & 13

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, D. Van Nostrand Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Warren, Charles E., Biology & Water Pollution Control, W. B. Saunders Co., Philadelphia, Pa., 1971.

Class Assignments:

Read Handout # 3
Work assigned problems.

Module No:	Topic: Effect of Man
Instructor Notes:	**Instructor Outline:**
Handout # 3 Transparancies #12 & 13 Show examples in: 1. Food supply 2. Population distribution 3. Preditation	1. Discuss how man can be a positive force in natural regulation using examples.
Show examples in: 1. Food supply 2. Population distribution 3. Preditation Emphasize differentiating regulated and unregulated disruption.	2. Discuss man's role in disrupting natural regulation in order to preserve the community.
	3. Give learner an example problem and have him identify: a. Food supply b. Distribution c. Competition d. Succession e. Disruption f. Preditation

Module No.:	Module Title: Natural Systems
	Submodule Title: Water Pollution
Approx. Time: 1 hour	Topic: History of Pollution

Objectives:

Upon completion of this module, the participant should be able to:

1. Define pollution.
2. Show the relationship of the industrial revolution to water pollution.
3. Cite evidence for the need for a system of water use classification and water quality standards.

Instructional Aids:

Handout # 4

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, D. Van Nostrand Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Warren, Charles E., Biology & Water Pollution Control, W. B. Saunders Co., Philadelphia, Pa., 1971.
4. Water Resources of Iowa, 1970.

Class Assignments:

Read Handout # 5

Module No:	Topic: History of Pollution
Instructor Notes:	**Instructor Outline:**
Handout # 4 1. Differentiate between pollution and contamination.	1. Discuss the history of pollution including: 1. Definition 2. Effect of the industrial revolution 3. Waste disposal 4. Law and regulation 2. Discuss the origin and basis of criteria standards for water quality. 3. Discuss the system of water use and waste water as a source of pollution.

Module No:	Module Title: Natural Systems
	Submodule Title: Water Pollution
Approx. Time: 1½ hours	Topic: Types and Sources of Pollution

Objectives:

Upon completion of this module, the participant should be able to identify the major types of water pollutants and their sources.

Instructional Aids:

Handout # 4

Transparancy #14

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, D. Van Nostrand Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Warren, Charles E., Biology & Water Pollution Control, W. B. Saunders Co., Philadelphia, Pa., 1971.
4. Water Resources of Iowa, 1970.
5. Turk, Turk & Wittes, Ecology Pollution Environment, W. B. Saunders Co., Philadelphia, Pa., 1972.

Class Assignments:

Read Handout # 5

Module No:	Topic: Types and Sources of Pollution

Instructor Notes:	Instructor Outline:
Handout # 4 Transparency #14	1. Discuss the classification of chemical pollutants as to: a. Non-degraded materials b. Nutrients c. Toxic materials 2. Discuss thermal, biological, and chemical pollution sources and the type of pollution associated with each.

Module No:	Module Title: Natural Systems
	Submodule Title: Water Pollution
Approx. Time: 3½ hours	Topic: Effects of Pollution

Objectives:

Upon completion of this module, the participant should be able to:

1. Identify "cause & effect" relationships of the 3 major classes of chemical pollutants discussed.
2. Examine an example of population or community adaption due to thermal pollution.
3. Compare sources, effects, and duration of direct and indirect biological pollution.

Instructional Aids:

Handout # 4

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, D. Van Nostrand Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Warren, Charles E., Biology & Water Pollution Control, W. B. Saunders Co., Philadelphia, Pa., 1971.
4. Water Resources of Iowa, 1970.
5. Turk, Turk & Wittes, Ecology Pollution Environment, W. B. Saunders Co., Philadelphia, Pa., 1972.

Class Assignments:

Read Handout

Module No:	Topic: Effects of Pollution

Instructor Notes:	Instructor Outline:
Handout # 4	1. Discuss the effect of the chemical pollutants as related to the following classifications: a. Non-degraded materials b. Nutrients c. Toxic materials
	2. Discuss the effect of thermal pollution on populations and communities.
	3. Explain, using examples, how communities and populations have had to adapt to a thermally polluted lake or stream in order to survive.
Differentiate between direct and indirect biological pollution.	4. Discuss the sources, effects, and duration of biological pollution.

Module No:	Module Title: Natural Systems
	Submodule Title: Water Pollution
Approx. Time: 3 hours	Topic: Corrective Measures for Polluted Waters

Objectives:

Upon completion of this module, the participant should be able to:

1. Describe the self-purification properties of a stream or lake.
2. Examine the need for and development in water and wastewater management.

Instructional Aids:

Handout # 4

Transparancy #15

Instructional Approach:

Lecture
Discussion

References:

1. Reid & Wood, Ecology of Inland Waters and Estuaries, D. Van Nostrand, Co., New York, 1976.
2. Ford & Monroe, Living Systems, Canfield Press, San Francisco, 1971.
3. Warren, Charles E., Biology & Water Pollution Control, W. B. Saunders Co., Philadelphia, Pa., 1971.
4. Water Resources of Iowa, 1970.
5. Sarai, Darshan, Ecology & Stream Purification, Water & Wastewater Technical School, Neosho, Missouri.
6. Chanlett, Emil, Environmental Protection, McGraw Hill, New York, 1973.

Class Assignments:

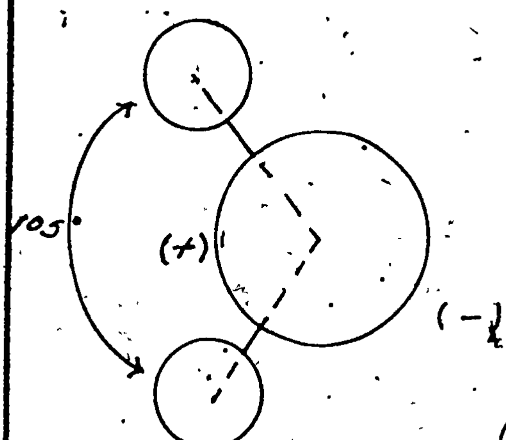
Read Handout # 5

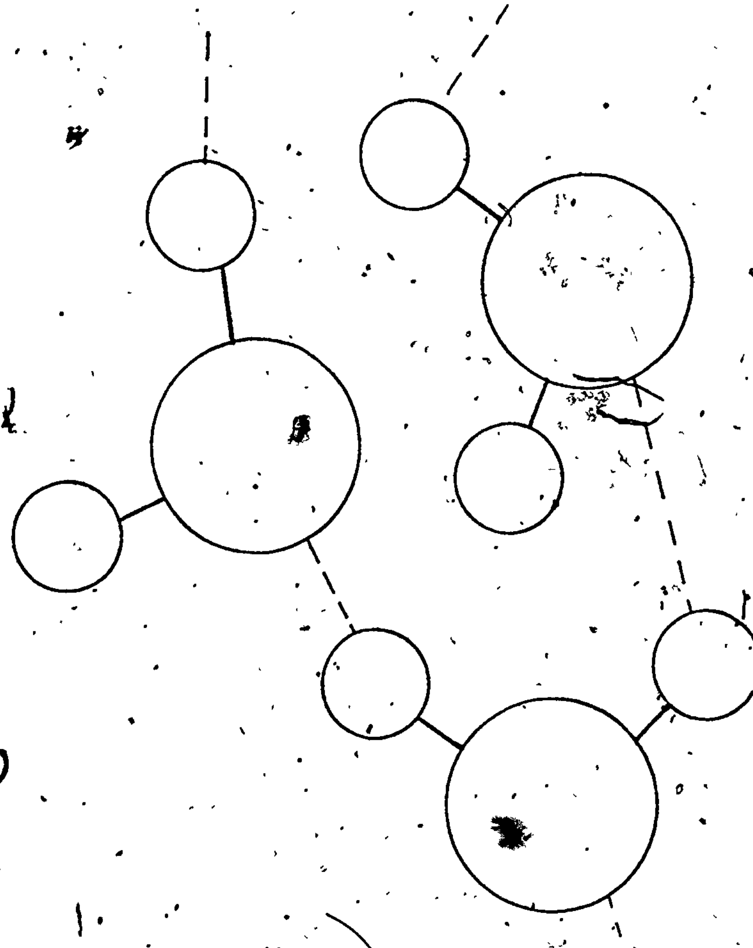
Module No:	Topic: Corrective Measures for Polluted Waters
Instructor Notes:	**Instructor Outline:**
Handout # 4 Transparancy #15	1. Discuss the organisms and their role in self-purification covering the following zones: 1. Clean 2. Degeneration 3. Septic 4. Recovery 2. Discuss water and wastewater management: a. The need for b. The development of

CYCLES IN NATURE

Water

Before looking at living systems, it is essential to first examine water as water is basic to all life. The water molecule is very simple in structure as it contains only 2 elements, oxygen (O) and hydrogen (H). In order to form water, two hydrogen atoms must combine with an oxygen atom. This process is termed bonding and the resultant water molecule has the following structure.





H_2O

This chemical symbol for water is written H_2O indicating not only the elements involved but proportions as well.

In relating water to life, however, discussing basic structure is not enough. Certain physical characteristics must also be examined. These characteristics include specific heat solvent action, density, cohesion, and surface tension.

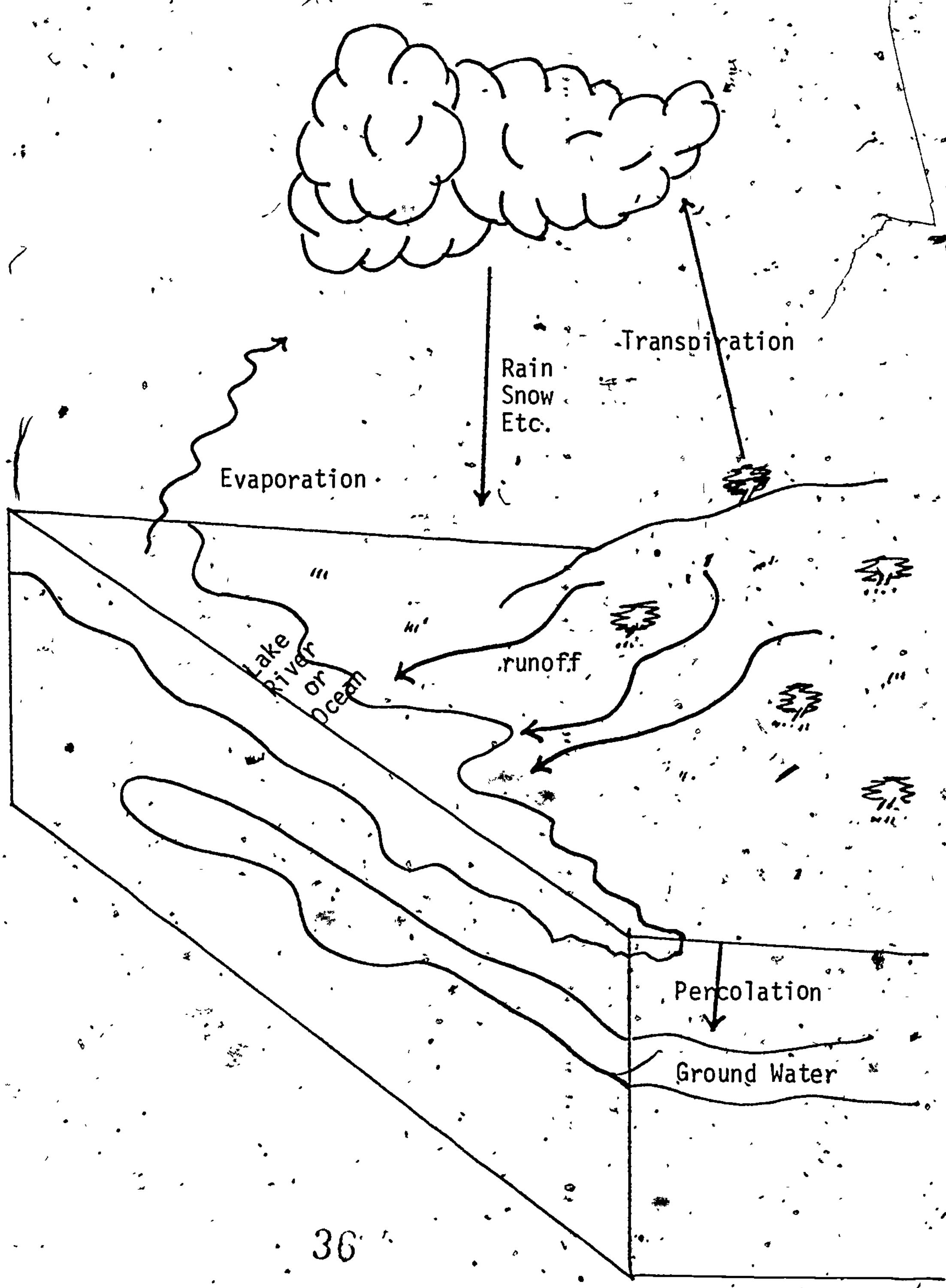
Specific heat is defined as the amount of heat energy required to raise 1 gram of water 1 degree centigrade. Water requires a great deal of heat energy to raise the temperature of 1 gram 1 degree centigrade; therefore, it is said to have a high specific heat. In other words, water can hold considerable heat energy without changing in temperature. This high heat capacity of water allows the water to act as a buffer to protect aquatic population from rapid temperature changes.

The ability of water to hold over 50 percent of the known elements in solution must also be considered. This is of great importance when the amount of nutrients taken into or released from living systems via diffusion is taken into consideration.

Density properties of water also play an essential role in living systems, especially with respect to life in lakes. The density of fresh water is unique in that the maximum density (weight per unit volume) is reached at about 4^{o} C.; therefore, frozen fresh water (ice) will float creating a situation where aquatic life can continue in the unfrozen depths of a lake.

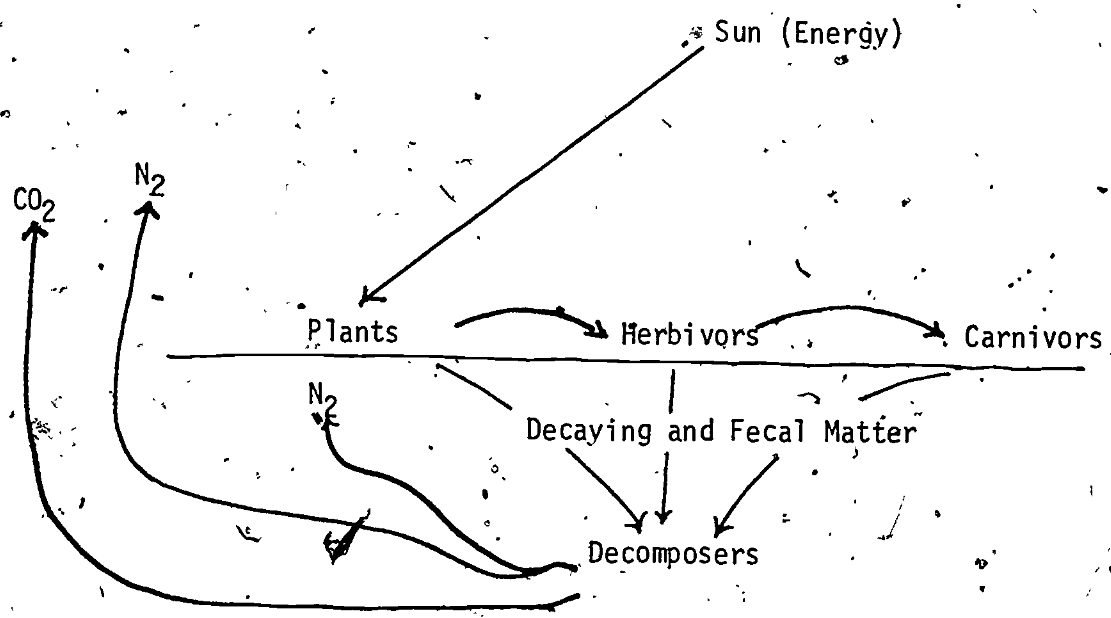
Cohesion and surface tension are terms used to describe the resistance of a fluid to being pulled apart. These two properties of water are essential for many living systems to exist. Plants for example rely to a great extent on cohesion in drawing moisture up from the roots and surface tension provides a firm surface on which to live for many small plants and animals.

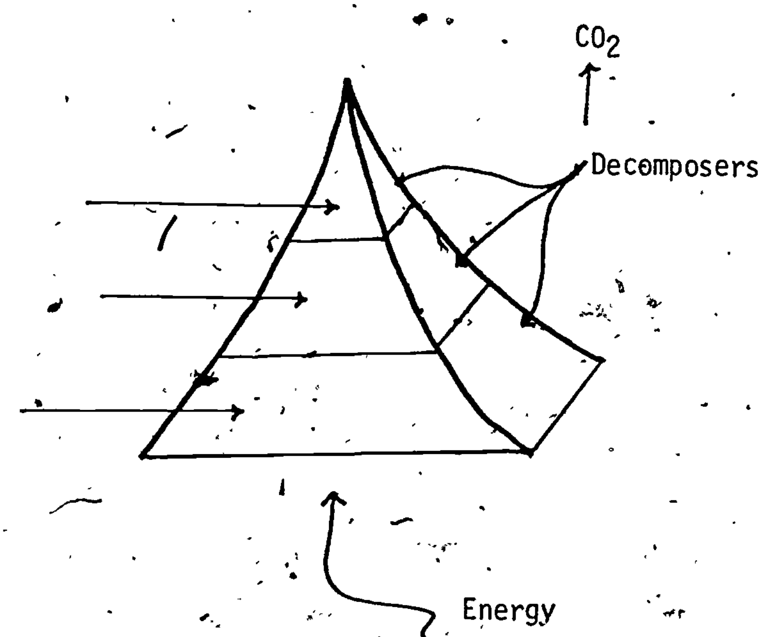
Since water is essential to life, it must remain an available entity. Water therefore, moves in a cyclic pattern. This is illustrated below in the hydrologic cycle.



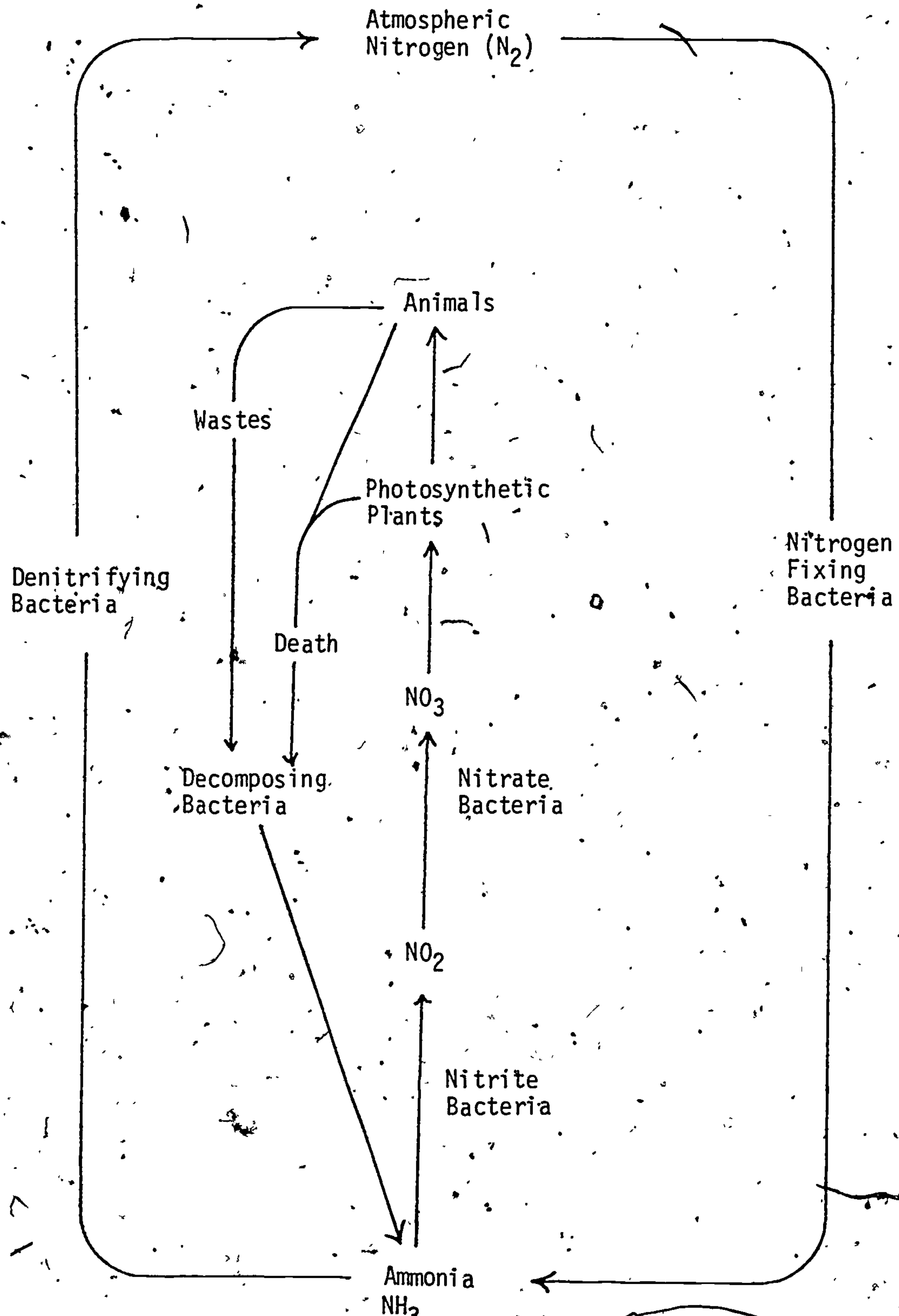
In addition to water, most nutrients also move in a cyclic pattern. Five examples of this follow.

The Food Chain and Ecological Pyramid

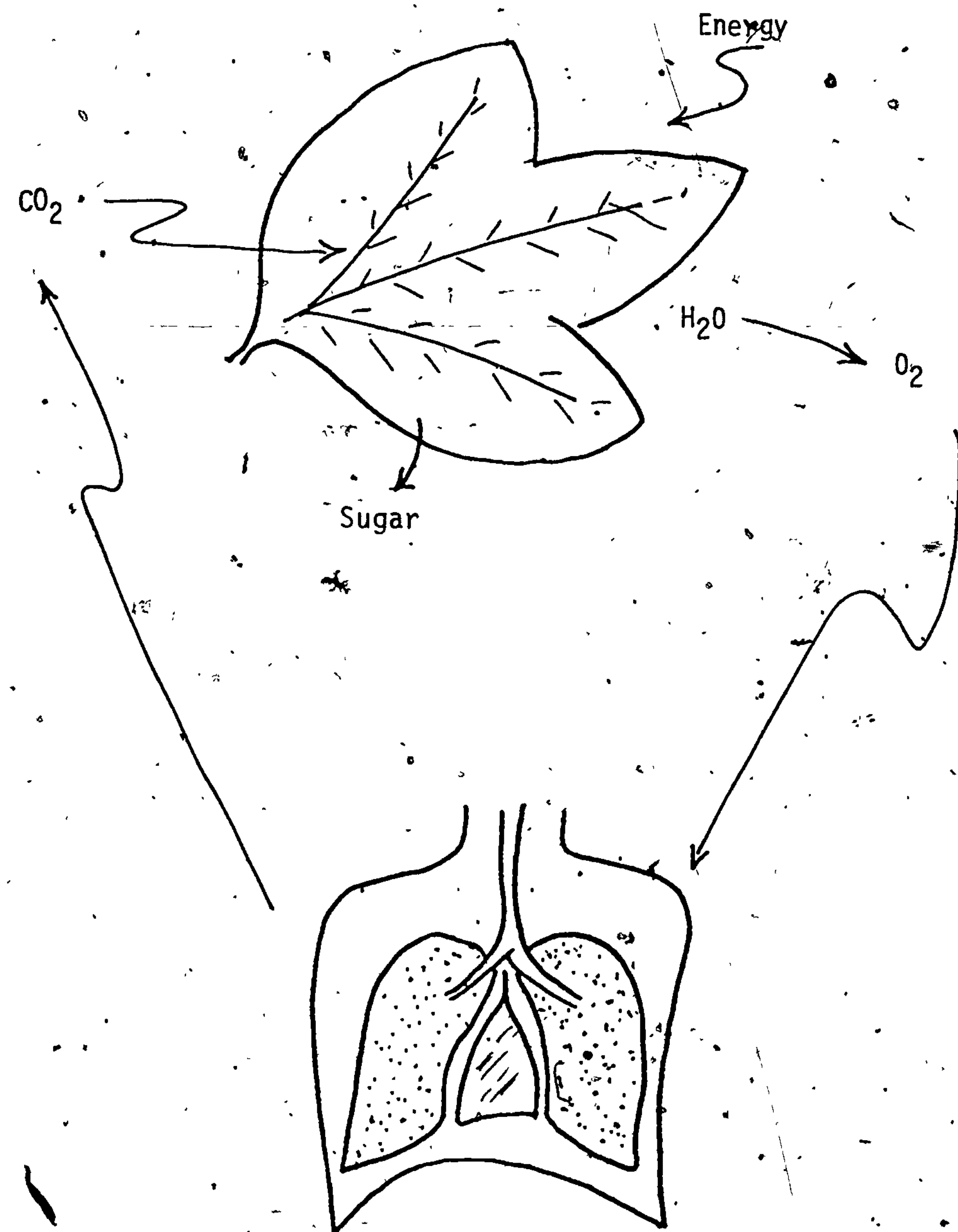




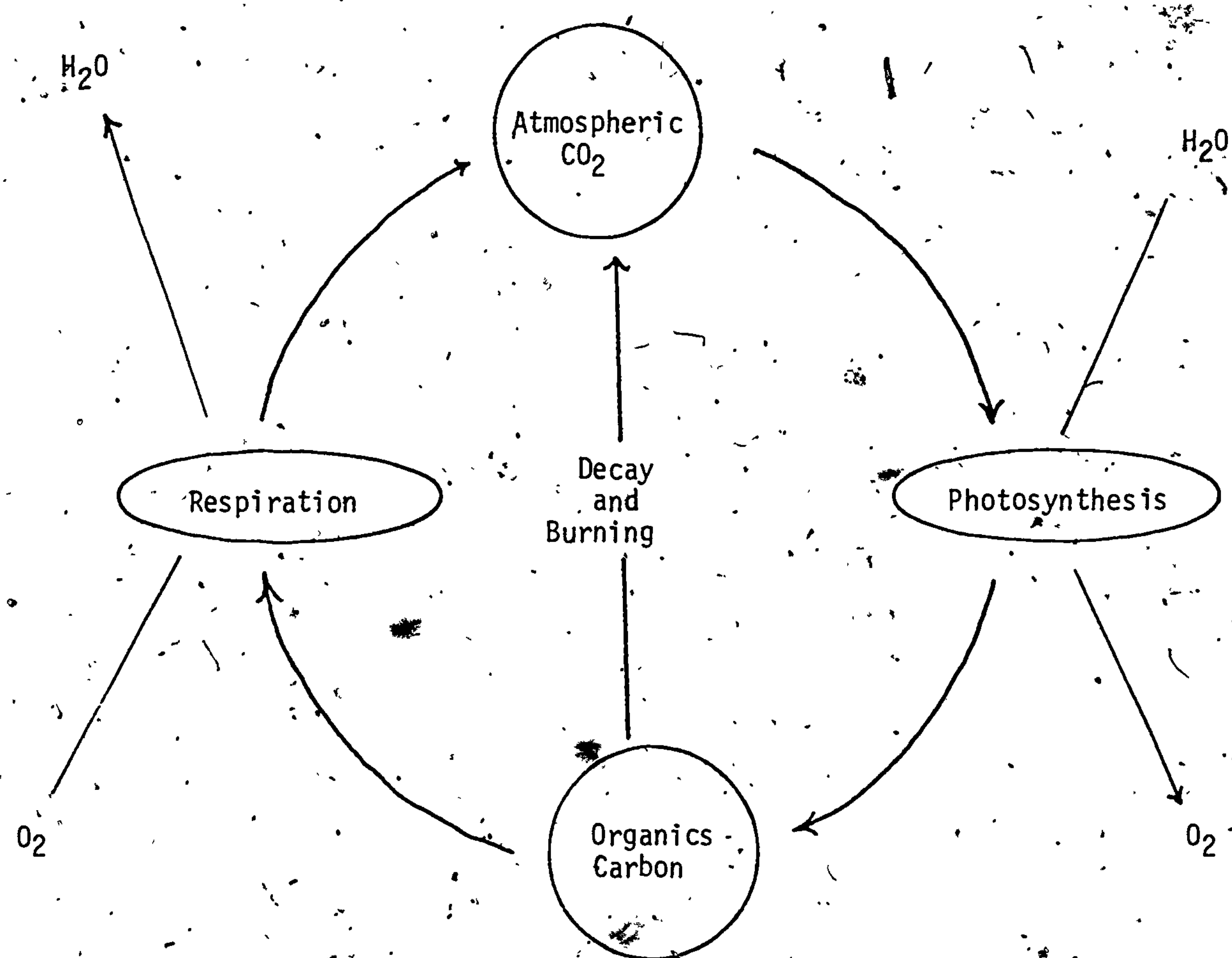
The Nitrogen Cycle



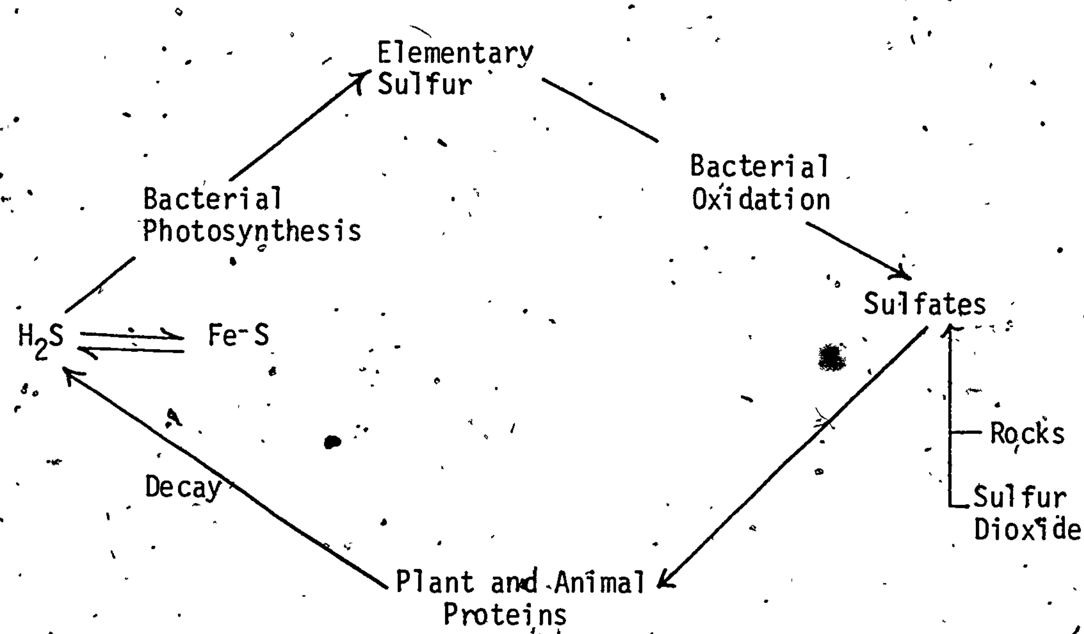
The Oxygen Cycle



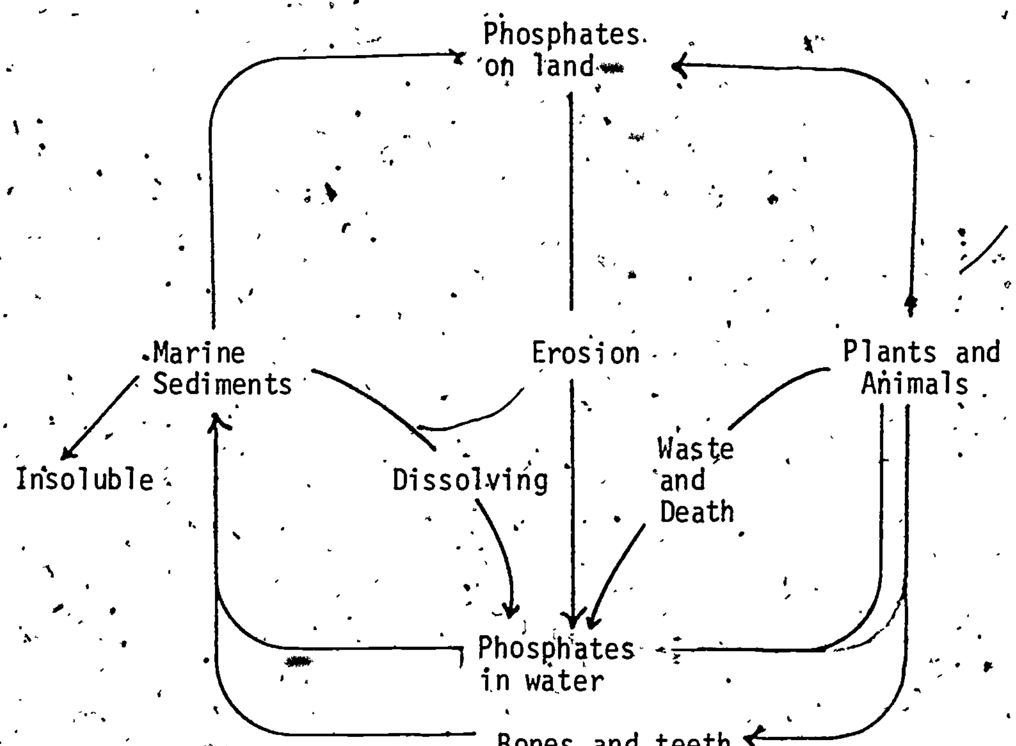
The Carbon Cycle



The Sulfur Cycle

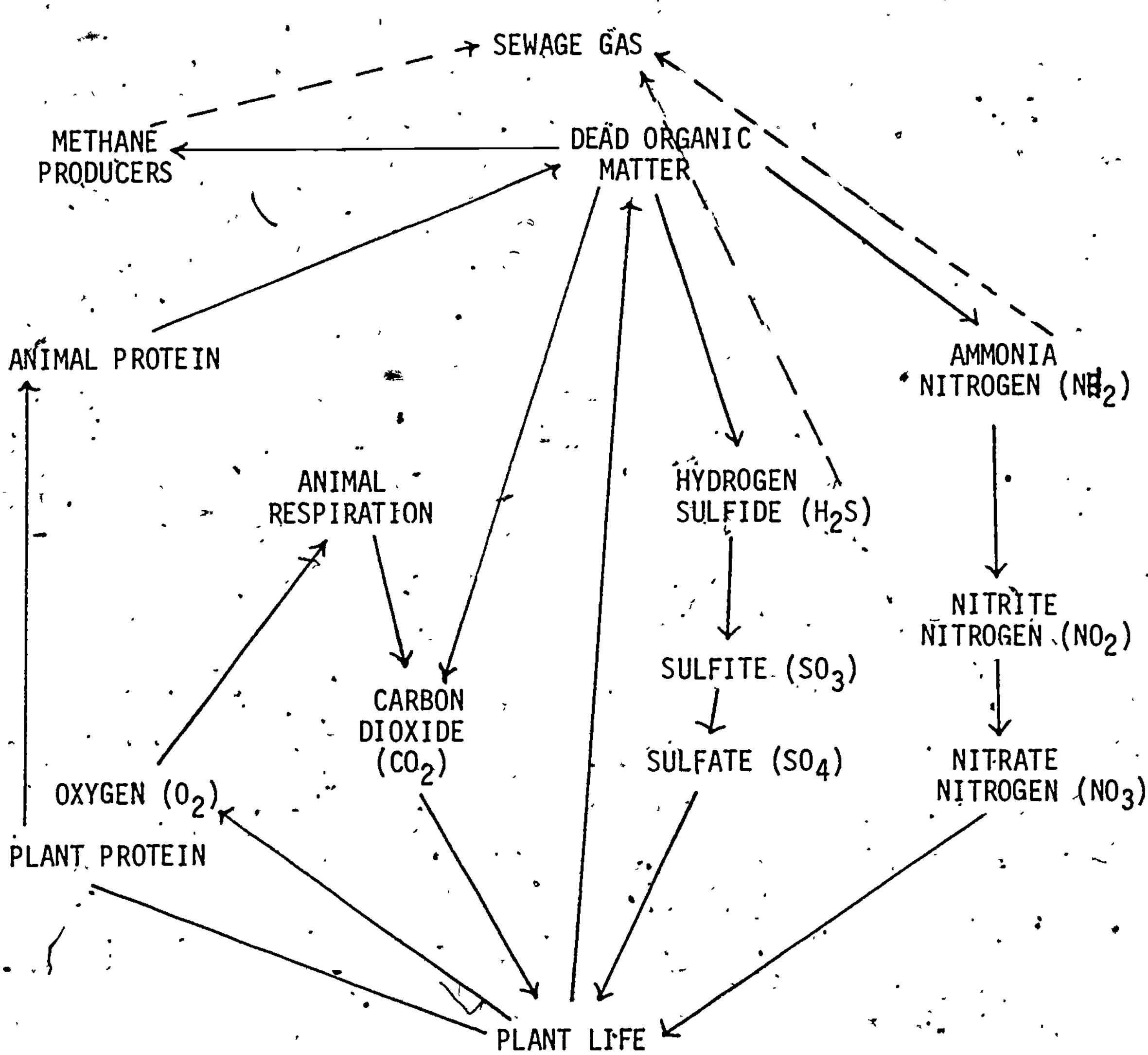


The Phosphorous Cycle



Practice Problem

On the following diagram trace the nitrogen cycle in red, the sulfur cycle in green, and the carbon cycle in blue.



THE NITROGEN, SULFUR, AND CARBON CYCLES OF DECAY

NATURAL WATERS

General

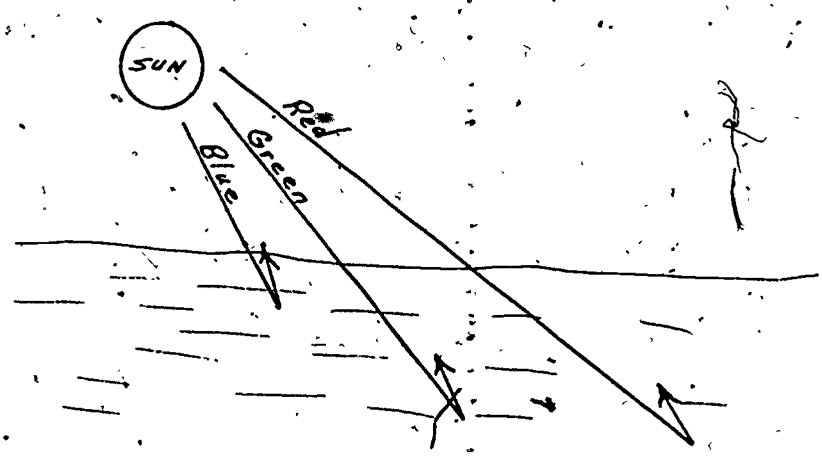
Natural waters can be described as a closed water system. Like shown in the hydrologic cycle, natural water moves in a continual cyclic motion. Natural waters include all phases of the hydrologic cycle. Water found in the atmosphere, in lakes and streams, as precipitation and as ground water can be termed fresh water and that found in the oceans and estuaries as sea water.

Natural water, therefore, is a finite or limited substance. Unlike pure water, natural waters vary in composition. Sea water and rainwater will vary the least due to their fairly constant environment. However, streams, lakes, and ground water vary a great deal from one area to another. This is due to the everchanging environmental conditions as the water moves through the different environments.

Solar Radiation and Color

The color of a lake is from unabsorbed light rays passing out of the lake from the original light entering the lake. Completely pure water will absorb all light that enters and appear nearly black. This is not seen in natural waters, they normally appear blue.

The observed blue color of lake water is the result of light scattered upward and selective absorption of that light. Scattering of light is a function of its wavelength. Blue light is scattered more than red light thus more blue light exists in the water before it is absorbed then red light. All colors of light is absorbed equally. This can be diagrammed as follows:



A second factor of lake color is the true color of the water. Lake water may be brown from dirt and soil, green from algae or red from iron. The observed color is a combination of the color from scattered light and the true water color.

Solar Radiation and Turbidity

Dissolved Gases

A great variety of gases are found dissolved in natural waters. Some such as hydrogen, nitrogen, NH_4 and H_2S occur in association with dissolved solids or biological activity; they will be discussed in the following section which is concerned with dissolved solids. The most widespread gases to occur in water under natural conditions are oxygen and carbon dioxide. In much limnological work, measurement of the amounts of these two gases present is the first step in any detailed study of the ecology of a lake.

Dissolved Solids

LAKES

Temperature in Lake

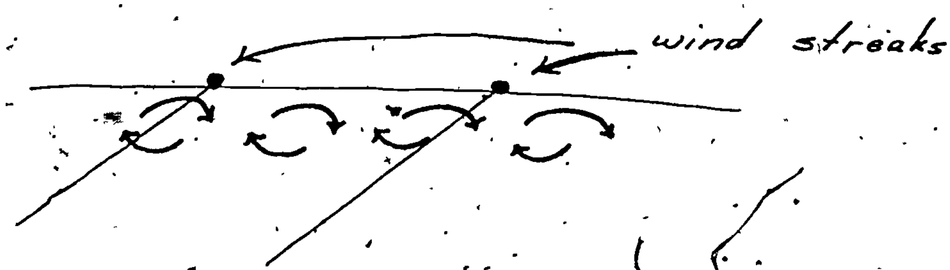
One of the most important phenomena found in lakes is the relationship between water and temperature as observed in seasonal variations. These variations or cycles cause pronounced seasonal changes in the lake. During winter, the temperature of the water in moderately deep lakes is relatively uniform from surface to bottom. If the lake is ice covered a cold top layer is found just under the ice. In spring, circulation and mixing of water results with a uniform top to bottom lake temperature. During summer a vertical distribution of temperature forms with warm on top and a cold layer on the bottom. The two layers are separated by a thermocline (zone of rapid temperature change) and there is no mixing between the warm and cold layers. The warm layer is termed epilimnion, the cold layer hypolimnion.

In the fall the lake once again returns to uniform temperature with circulation and mixing.

Movement

Density currents result from water of a differing density entering a water body. The differing density may result from temperature or high solids concentrations.

Wind streaks (langmuir lines) or a phenomenon resulting from wind. Water flow is in the form of helices lying parallel to one another oriented in the direction of the wind. The direction of the nelices are alternating clockwise and counterclockwise. The streaked appearance is caused by accumulation of materials in zones of convergence. This can be diagrammed:



Surface waves are the common wave cased by wind moving across the lake. There is no essential horizontal movement of water with waves.

Seiche (pronounced "sāsh") is periodic current system described as a standing wave in which some stratum of the water in a basin oscillates about one or more nodes. This rocking motion is similar to the motion in a bowl of water when it is bumped.

Dissolved Oxygen

Of all the chemical substances in natural waters, oxygen is one of the most significant. The oxygen available for metabolic relationships in natural waters is the water in solution not the oxygen in H_2O, water. The volume of oxygen dissolved in water at any given time is a function of temperature of the water, atmospheric pressure, salinity and biological activity.

The solubility of oxygen in water is increased with lowering temperature. The amount of oxygen water can hold at 20° C. is 9.2 mg/l, at 5° C. is 12.9 mg/l.

There are two sources of oxygen in lakes. The first is wind and wave action, the second is plant life. Oxygen is depleted in a lake by animal life and by plants at night.

Classification

Lakes can be classified according to a system based on productivity, its causes and its effects. In a sense this is an historical system as well because many lakes are at different times oligotrophic, mesotrophic or eutrophic.

Oligotrophic lakes (from the Greek words meaning "low in nutrients") support relatively low rates of photosynthetic productivity. As the name implies, in these lakes productivity is limited by the supply of nutrients. More specifically, the limiting material is usually phosphorous in oligotrophic lakes.

In an historical sense, oligotrophic lakes are thought of as "young" lakes. Lakes have frequently been created by drastic, geological events, such as glaciation, that leave uneven land surfaces and depressions that can contain lakes. Such events often create infertile landscapes that can support abundant life only after colonizing organisms have broken down rough cover materials into reasonably fertile soils. In such infertile environments, lakes often have meager nutrient budgets and are therefore oligotrophic.

Mesotrophic lakes are more productive than oligotrophic lakes, because they generally have larger nutrient inputs. They support moderate populations of algae and of consumer animals. Moderately productive, mesotrophic lakes are nutrient limited as are oligotrophic lakes. Phosphorous again usually limits algal productivity, but input rates are higher than those for oligotrophic lakes.

Mesotrophic lakes may develop periodic algal blooms--noticeable population increases that reduce water clarity.

Eutrophic lakes (from the Greek word meaning "well-nourished") are those that are highly productive because they have abundant nutrient supplies. Algae or macrophytes grow so thickly in some eutrophic lakes that light penetrates only a short distance and nutrients below that depth are used inefficiently. Photosynthesis in some of these lakes is therefore probably limited by light rather than by nutrients. In other eutrophic lakes nitrogen rather than phosphorous may be a limiting nutrient. This means that nitrates and ammonia, the nitrogen forms that are used by most algae, are used up before phosphate is in such lakes certain species of blue-green algae that can fix atmospheric nitrogen have a clear competitive advantage and frequently become dominant.

Eutrophic lakes show wide seasonal changes in chemical conditions. Because of the great amount of organic matter produced in these lakes, much decay occurs in the hypolimnion. Therefore, eutrophic lakes frequently show almost complete loss of dissolved oxygen below the thermocline during summers. Clearly, fish and most other animals cannot live in the hypolimnion of such lakes.

Warm-water fish that can live in the epilimnion, however, can be quite productive. Bass, panfish, pike, walleye, carp, and bullheads thrive in many eutrophic lakes.

A eutrophic lake is said to be an "old" lake--while an oligotrophic lake is "young".

A lake created by glaciation, for example, may begin as a rugged, rocky, or gravelly basin in an infertile landscape. Plant and animal productivity is low at the start. Over a period of time the land changes--developing fertile soils and active biological communities; meanwhile the lake basin has become shallower because of the accumulation of plant and animal remains. Shallow lakes are likely to be more productive than deep lakes because there is greater likelihood that bottom-feeding fish will recycle algal nutrients to the epilimnion if the vertical distance is short, and because shallow lakes have less water to dilute incoming water, which usually has higher nutrient concentrations than the lake itself.

It is important to realize that many lakes have become more productive because of various recent human disruptions. "Eutrophication" is an appropriate name for this progress, but "aging" is not. The increases in productivity do not create a marked decrease in depth; therefore such artificial eutrophication can often be terminated, without leaving permanent effects related to decreased depth, merely by controlling nutrient inputs.

8

STREAMS

Origin and Morphology

Most streams form their own channels. This occurs because the water erodes the land as it moves across the watershed as runoff. The erosion of the land during this is of two types -- mechanical and chemical. Speed and type of erosion are dependent on a variety of variables including water and ground composition, climate and slope.

Young streams usually, therefore, reveal steep sides which tend to erode to flatter slopes as the stream matures due to seasonal flooding. With this process, also the logitudinal gradient decreases. As this aging process continues the stream channel becomes almost flat due to continued widening and deposition. An old stream therefore has a very limited carrying capacity.

Stream length will vary greatly but the course can be divided into 3 basic regions upper middle and lower. Change in velocity, gradient, and deposition can be noted as the water flows down the stream.

Patterns in river development can be related to the surrounding geological formations.

Size, Movement, and Temperature

The basic properties of temperature cycles are similar to those found in lakes since direct solar radiation is the major factor in warming. Temperature fluctuations in the large rapid flowing streams are minimized though due to the volume and turbidity of such a system. Also in the same respect, it can be noted that as the stream size decreases, this fluctuation increases. Regardless of size, thermal stratification is minimized due to the turbulance caused by the flow.

Source of the water being fed into the stream must be considered along with size and movement with regards to temperature variation. Streams fed by ground water tend to vary less in the annual temperature cycle than those fed by other surface water sources.

Dissolved Oxygen

Similar to lakes, oxygen is a significant substance necessary for aquatic life. It also varies as a function of the same variables in lakes. In streams there are 3 primary oxygen sources; water source, photosynthesis and turbulance.

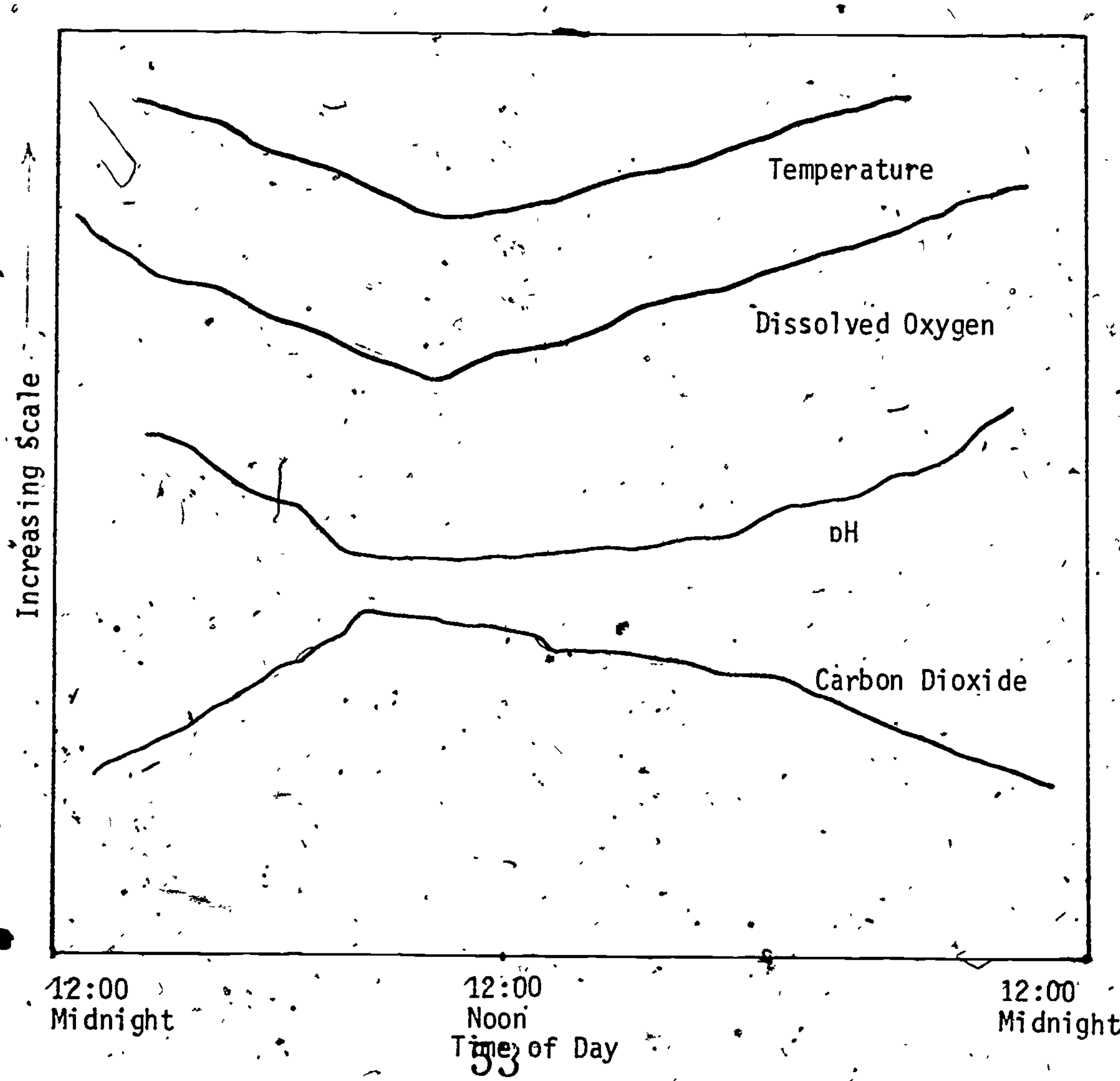
Water source, whether it be ground water or surface runoff, as an insignificant source of oxygen. Photosynthesis varies with the amount of plant life present. Turbidity then plays an important part in reaeration as oxygen is taken directly from the atmosphere and made available for use by the aquatic ecosystem.

Like lakes dissolved oxygen content tends to increase by day and then deplete at night creating a cyclic curve.

Carbon Dioxide and pH

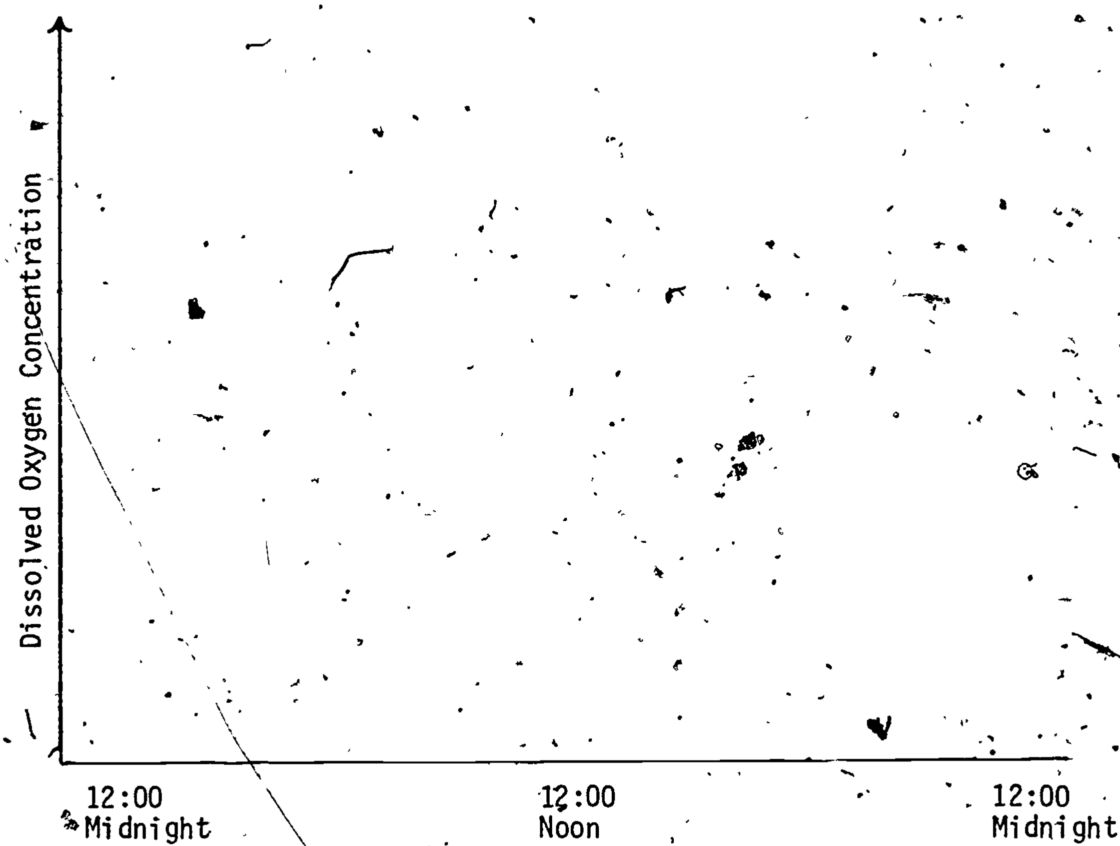
pH varies inversely with the carbon dioxide content. However carbon dioxide content fluctuates with respect to the surrounding geologic formations, current, photosynthesis; and separation as does oxygen content but with inverse properties.

Regardless of whether surface water is in a stream or lake, dissolved oxygen, temperature, ph, carbon dioxide, and movement can be related as shown on the following graph.



Practice Problems

1. Stream "C" has deep rapid flowing, and has an abundant algae growth and fish population. Assuming no oxygen consuming waste is dumped into the water diagram a typical daily dissolved oxygen concentration on the following graph.



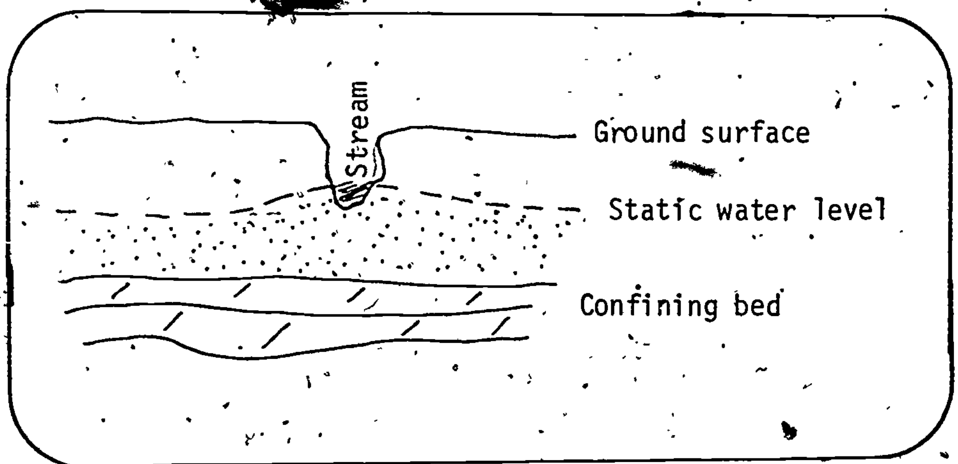
2. On the same graph diagram the dissolved oxygen curve for Lake "B" where conditions are stable.

GROUND WATER

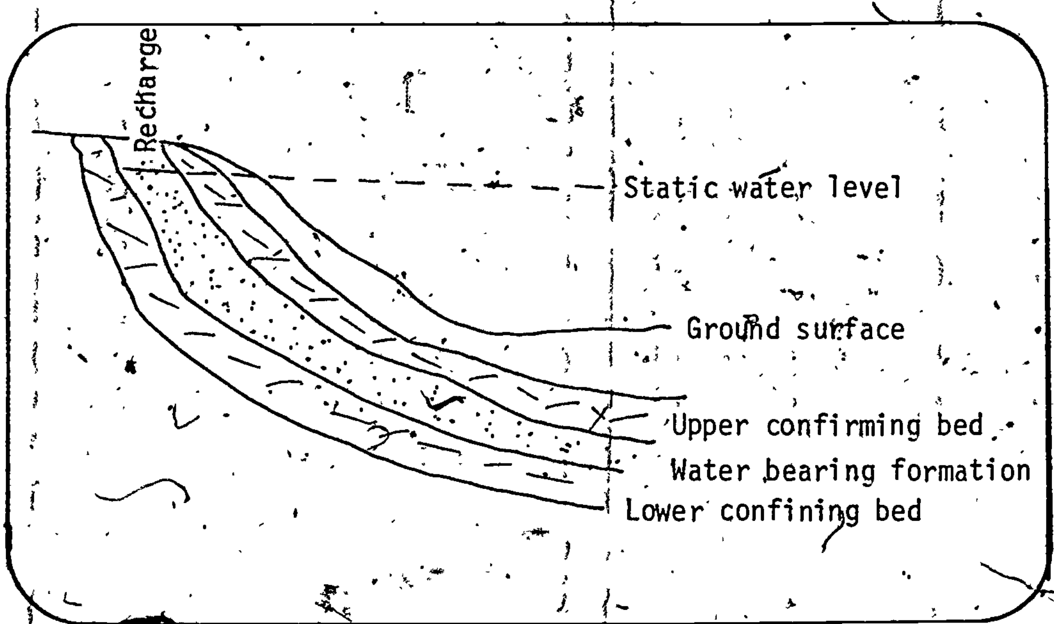
Formation Morphology

Groundwater formations are grouped together as a whole and termed aquifers. There are 2 basic types of aquifers -- water table and artesian.

A water table aquifer can be described by the following diagram.



The artesian aquifer differs from the water table in that it has an upper and lower confining bed. This leads to a pressurized system.



Aquifer Functions

Storage is the aquifers first function. This function is described by two terms.

Porosity is defined as the portion not occupied by rock. It indicates how much water the formation will hold and is affected by partial uniformity and arrangement. Specific yield is how much water aquifer will yield when drained by gravity. That water which is retained is the specific retention.

The aquifer also serves as a water conduit. Two different terms describe this function also.

Permeability is the capacity of the yield when a difference in head occurs. Change in permeability is proportional to change in difference of head and is affected by the particle size. Transmissibility is the rate of flow in gallons per day through the aquifer.

Movement

The movement of water through the formations is very slow yielding a balance of chemical concentrations between the formation and the water.

AQUATIC ECOLOGY

Natural Populations

A population is defined as a group of individuals which interact and interbreed. Individuals of any given population share the following: The same genetic pool, similar stimuli responses, the same habitat, similar morphology, and particular behavioral characteristics.

Population survival is due to adaptability to changing environmental conditions. Survival ability is coded in gene pool. Therefore survival is a function of the population rather than the long individual.

Population Interactions

Population growth and regulation is dependent on the following factors: Birth rate - the rate of reproduction by any given population, food supply - the amount of usable food stuff available to any given population, preditors and disease - any living entity which survives by destruction of the population in question, life span - the time from birth till death, distribution - the area over which any given population is distributed.

The birth rate of a population will decrease with a decrease in food supply. Therefore, a dramatic increase in the total population will limit food supply and act as a limiting factor for birth rate. Also since the birth rate peaks then decreases during the life span of each individual, the average age of a given population can play a role in birth rate.

Preditors and disease serve to shorten the life span of the individuals of any given population thereby shortening the reproductive span leading to fewer progeny. Their injury can also debilitate and lead to a lowering of the birth rate.

Distribution of any population also plays a distinctive role in population growth and regulation. Any given area is capable of producing sufficient food supply and nesting areas for a particular size of population. When this is exceeded the food supply and nesting areas are insufficient and the birth rate in turn declines. If not, the area of distribution is expanded and must be shared with other populations. Preditation, remember, increases as the distribution increases, again leading to growth regulation.

The populations also have other direct relationships to each other in addition to those seen in growth and regulation. These relationships are grouped into several categories of which, we will examine the following: Symbiotic, saprophytic, commensalitic and parasitic.

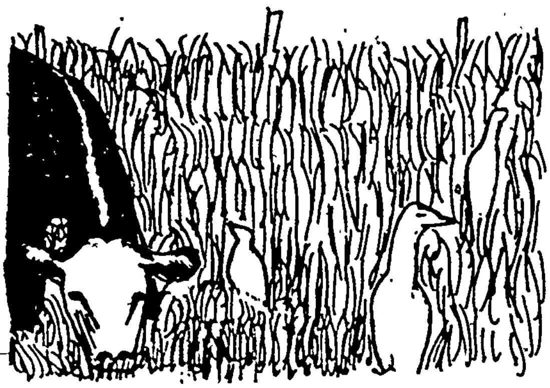
A symbiotic relationship is one where two dissimilar organisms live together in harmony.

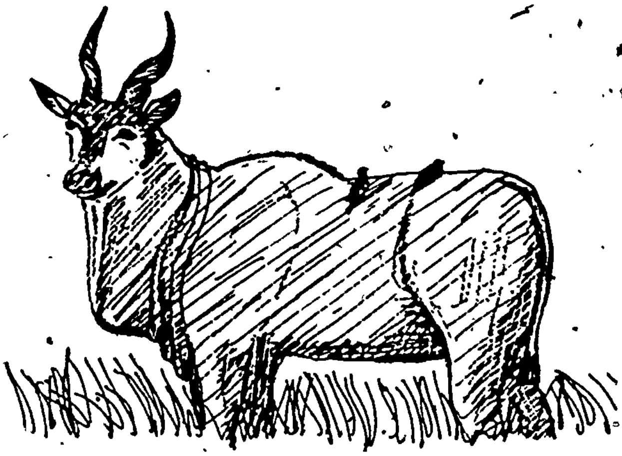
A saprophitic organism is one which obtains its food from dead organic matter (another organism).

And a parasitic relationship is one in which one of the two dissimilar organisms living together is benefited but the other is harmed.

These relationships can be illustrated as follows:

Symbiotic Relationships

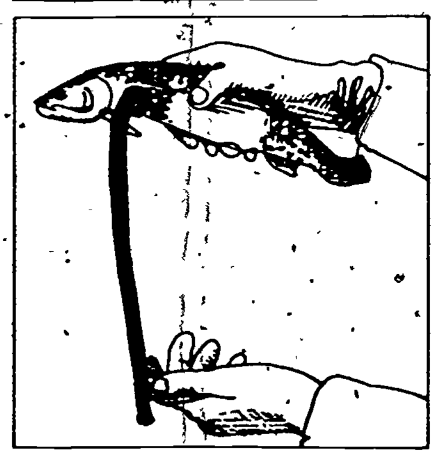




Commensalism: The cow stirs up insects for the geese

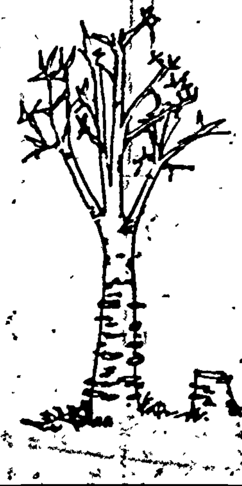
Naturalism: The bird eats the parasites off the back of the elk.

Parasitic Relation



The sea lamprey lives by sucking the blood of the fish, eventually killing it.

Saprophytic Relation



The mushroom is deriving it's food from the dead tree on which it is growing.

As several populations live together each develops its niche or occupation within the community. Also a system of dominance is set up where one or more (co-dominance) populations control the community. In this type of system each population takes its place in the food chain or energy flow.

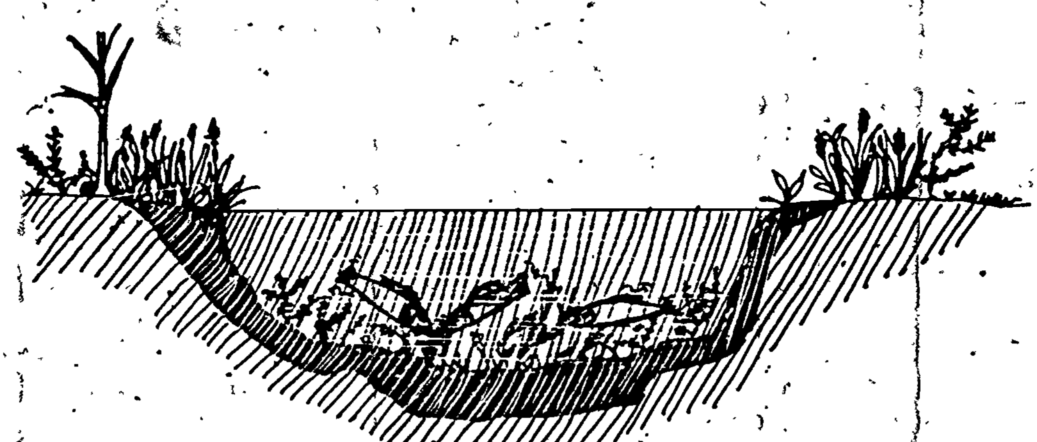
Communication is another form of population interactions. Communication takes place within any given population or between different populations within a community and can be looked at as a response to stimuli. Examples of this can be seen everywhere in nature. The hiss of a cat when approached by a stranger, the folding of some plant leaves on touch, the call of a duck, and the color change as fruit ripens, are all examples of communication not only within a population but between the populations.

From the previous discussions of various forms of population interactions it should be obvious why populations do not live in isolation from other populations. Just as an individual relies on other individuals for support in life, populations show the same dependence on other populations. Therefore, compatable groups of populations interact to form community life.

Community Life

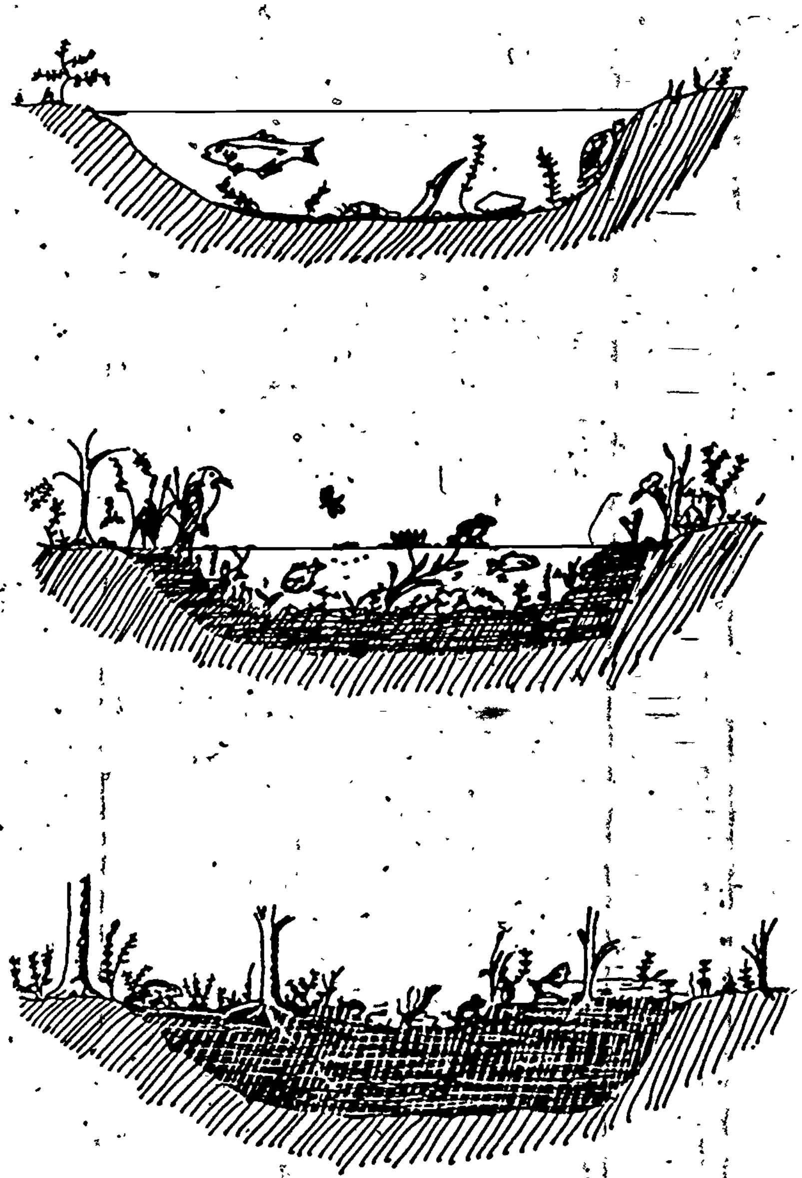
A community can be described as a group of interdependent populations which have colonized a given location. A community's survival is dependent on environmental conditions in that location. Therefore, as conditions change the community changes. New populations appear, the old disappear and the overall changes in the community determine its survival due to massive population interrelationships within the community.

As briefly mentioned in the discussion of populations, community life is controlled by dominant populations. Dominance should not be confused with predominance. The predominant population in a community is simply the one with the greatest number. The dominant population on the other hand, controls the community environment and thereby other populations which may enter the community. An example of dominance can be seen by the following:

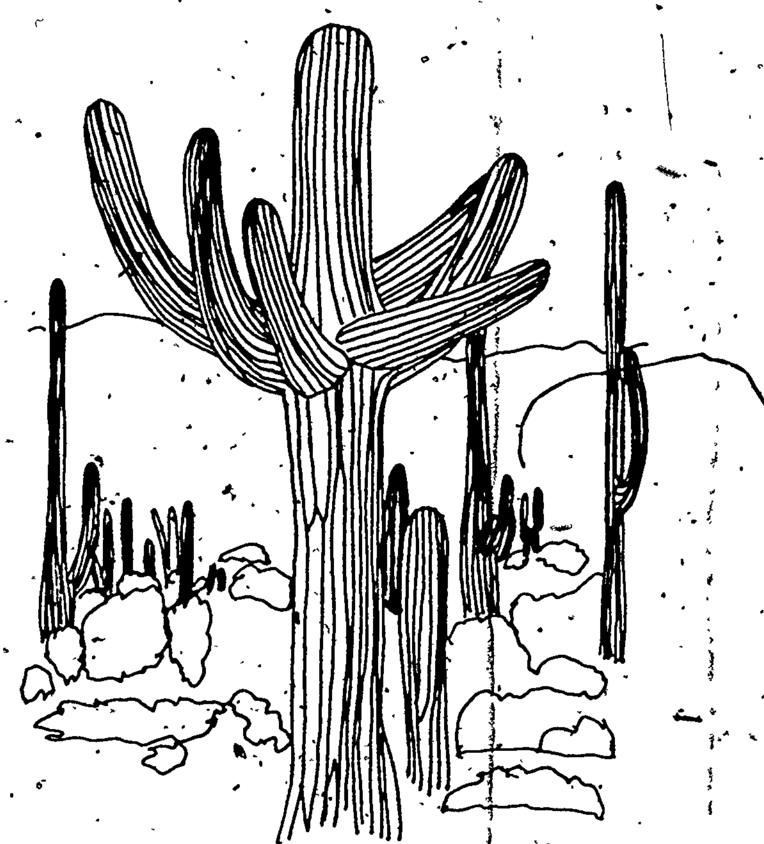


Control of the community can also be split between two or more populations. When this is evident we are looking at a system of co-dominance. An example of this is illustrated below.

Living communities are continually changing to meet with the requirements of a changing environment. New populations move in and old populations are forced out. This community change is termed succession.



As succession of a community continues a more and more stable and more complex community is formed. An end point of sorts is reached when the community develops into a stable, self-repairing system. This then is termed a climax community. An example of such a community is illustrated below.



Eco-system Balance

We have already examined food supply, birth rate, population distribution, etc. as they relate to growth and regulation of the population. Now let us look at them as they relate to balance within a community and an entire eco-system.

The food supply for any one population is only a part of the massive food web of the community. Food, as energy, flows from one population to another. As illustrated in the food chain, the plants use the products from microorganisms, the herbivores eat the plant materials, and the carnivorious population consume the herbivores and other small animals. Any break in this cycle endangers the existance of the entire community. Seasonal changes also help regulate the balance of the eco-system. In many communities populations change with the seasons. This is mainly due to alterations in temperature and light. These changes are also cyclic and result in little, if any, permanent environmental changes. However, balance of the eco-system depends on these cyclic changes.

Population diversity also adds stability to the community eco-system. A more highly diverse community is able to withstand greater environmental changes without adversely affecting the integrity of the community than one with less diversion.

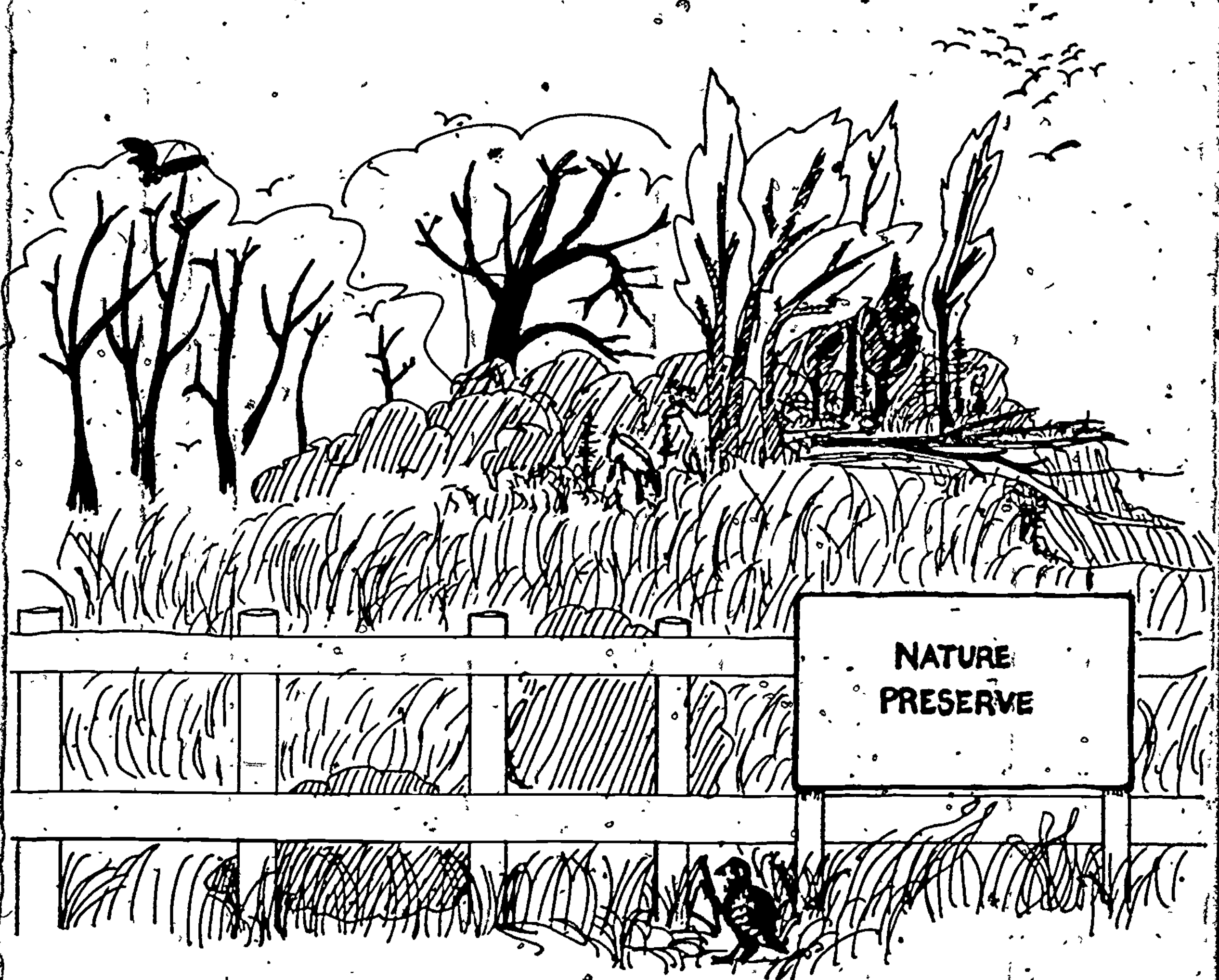
The birth rate, life span, and loss through preditation and disease also play distinct roles in eco-system balance. As long as the physical state of the environment remains constant, it is these factors which keeps the biological systems in balance.

These basic aspects of balance in an eco-system can be diagrammed in the following illustration.

Effect of Man

In the course of history, man has exerted both positive and negative effects on the surrounding aquatic eco-systems. Unfortunately, it has been the detrimental effect which have been publicized. This will be discussed later under pollution.

The beneficial effect of man can be looked at in two ways. Man is capable of being a positive force in natural regulation. This can be illustrated by the following situations.



Man also is capable of disrupting natural regulation to the benefit of community or any given population. The following situations illustrate this concept.

WATER POLLUTION

History

Since life is impossible without an adequate supply of fresh water, man's activities have always been centered around this precious commodity. Records as early as 2000 B. C. describe methods of purifying water and modifications of this continues through today. Water, however, has not always been considered a limited commodity. There has been many instances in history where man has simply moved on when his activities fouled the water to the point where it was no longer usable. Today's society has forced man to recognize the value of water, conserve its use, and reclaim its quality before returning it to the environment. Failure to reclaim used water leads to continued fouling or pollution of the environment which can no longer be tolerated.

Pollution is a term which can be applied to all phases of the environment including air, water, noise, etc. Pollution has been defined in a variety of terms throughout history. Many times incorrectly where emotions took precedent over rational. The most commonly accepted definition today could be worded as follows:

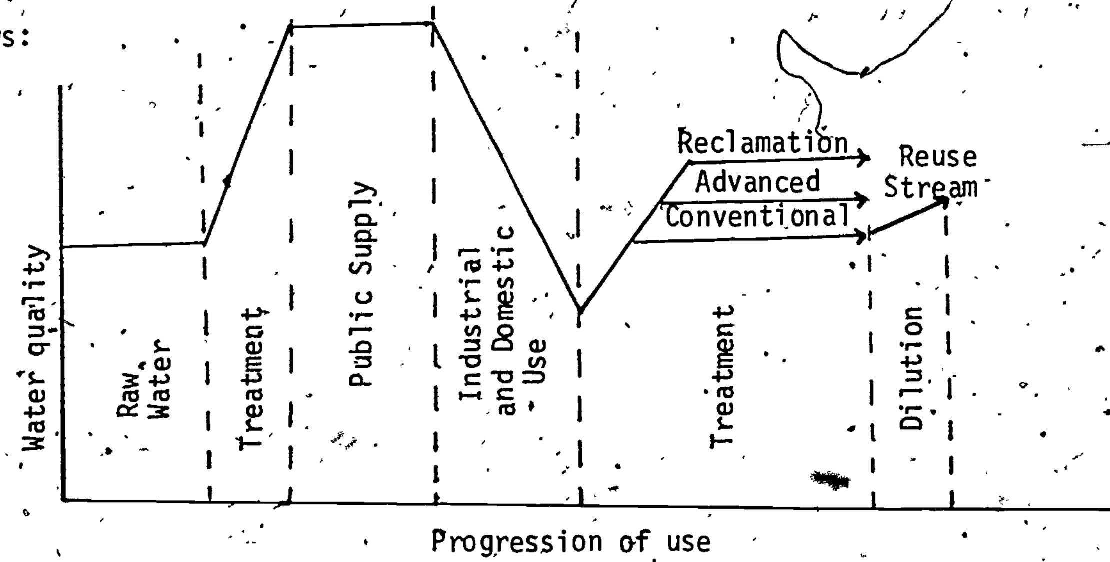
> Pollution: The introduction of a substance into a valuable community in such concentration that one or more environment changes occur causing an adverse effect to that community.

This definition can be illustrated by looking at any type of pollutant. Let us look at the situation with water.

Historically, water pollution has been proportional to the development of human society. Primitive man, wandering alone or in small groups, created little pollution effects as nature could readily decompose the potential pollutants he created. With the advent of communal societies and eventually the industrial revolution these potential pollutants reached the crucial concentration and began adversely affecting the surrounding environment. Communities were required to change or become extinct.

From this it is evident that some type of control of the dumping of pollutants had to be developed. Also, water use classification became necessary as our lakes and streams were being forced to the limits of their self-purifying abilities. Since our surface waters are reused several times, laws regulating the use of these raw waters and the dumping of wastewater into them were created.

The regulations governing wastewater disposal allow for some use of the receiving waters for final purification but the majority of the degradation is done artifically in treatment facilities in order to protect the community life of the receiving stream. This can be illustrated as follows:



Surface water will vary in quality due to naturaly occuring pollution as well as man-made problems. Therefore, it has been necessary to regulate the quality with respect to use of raw waters in order to protect man from harming himself even further. These regulations are based on intended use since a higher level of pollutants can be allowed in a potable water supply where the water will be treated before consumption than in a shellfish harvesting area from which the shellfish are often eaten raw. This can readily be illustrated by examining the maximum allowable limits for coliform bacteria in the various intended uses.

Potable water - [illegible]/100 mls.

Shellfish harvesting - 70/100 mls.

Recreation - 1000/100 mls.

Fish & Wildlife propagation - 5000/100 ml.

Raw water - 10,000/100 mls.

<u>Water Pollutants</u>

The types of water pollutants can be classified in a variety of ways. The following discussion will look at chemical pollutants, biological pollutants, and thermal pollutants with respect to sources of each and their direct and indirect effects on the surrounding communities. Some of the major pollutants, their sources and effects can best be summarized as follows:

Pollutant Type			Major Sources	Primary Effects
Chemical	Nutrient	Nitrogen and Phosphorous Compounds	Agricultural runoff Domestic wastes Industrial wastes	Algae blooms and excessive weed growth
	Non-degraded Materials	Inorganic Suspended Solids	Mining drainage Land erosion	Turbidity which interferes with photosynthesis and blanketing which smother bottom life activities
		Oxygen Consuming Matter	Feedlot runoff Domestic wastes Industrial wastes	Depletes dissolved oxygen in receiving waters thereby stiffling aquatic life and producing unpleasant tastes and odors.
	Toxic Materials	Acids and Alkalis	Industrial wastes Mining Drainage	Fluctuations in pH eliminating less tolerant species
		Nitrates	Agricultural runoff Industrial wastes Domestic wastes	Nitrate poisoning leading to death of infants and animals
		Chlorides and Sulfates	Industrial brines Urban street runoff (winter)	Tast impairment and laxative effects
		Heavy Metals i.e. Mercury Lead	Industrial Wastes	Toxic to humans Mercury: Compound stable and cumulative Lead: Inhibits bacterial decomposition of organics

- Continued on next page -

Pollutant Type			Major Sources	Primary Effects
Biological	Microorganisms	Pathogenic Bacteria	Domestic wastes Feedlot runoff.	Disease Transmission
		Algae Blooms	Side effect of chemical pollution (nutrients) or thermal pollution	Increased depletion of dissolved oxygen leading to stress of other aquatic life and production of taste and odor-producing compounds
	Higher Plants and Animals	Decomposing Aquatic Animals	Side effect of chemical pollution (depleted oxygen or toxic materials)	Putrification of stream or lake
		Excessive Weed Growth	Side effect of chemical pollution (nutrients) or thermal pollution	Increased depletion of dissolved oxygen leading to stress of other aquatic life and production of taste and odor-producing compounds
Thermal	Heated Water Discharge	Increase in natural water temperature	Industrial and power plant cooling waters	Accelerates depletion of dissolved oxygen, growth of blue-green algae blooms, taste and odor production, and stress on oxygen dependent aquatic life.

Corrective Measures

Questions are continually raised as to what can be done to correct the pollution problems man has created. Also methods of determining to what extent the pollution is altering the communities of the lake or stream are being investigated.

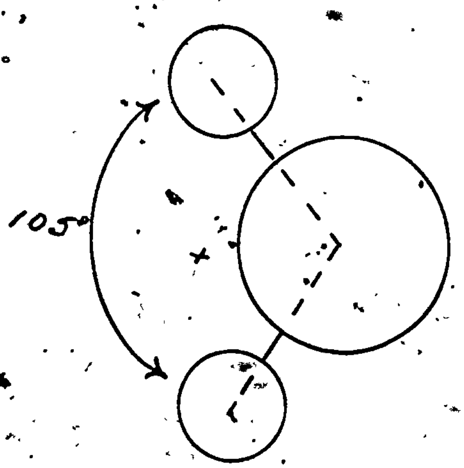
As far as man is concerned, little can be done to correct the affects of those pollutants already introduced into the lake or stream. Prevention of new pollutants entering is the best corrective measure for already polluted and still clean waters.

This raises the question how can man determine if the potentially polluting wastes are in fact polluting the lake or stream? A variety of biological indicators have been developed to aid in this determination. Researchers have examined communities before and after pollutants have entered and found that the populations in the community react differently to the various pollutants. As the pollution concentration increases the populations of the less resistant species are decreased leading to an increase of the more resistant species if the preditors are eliminated by the pollutants. There are other cases of the more resistant species increasing in numbers due to less competition also. Whatever the underlying reason for this increase the cause is the pollutant concentration.

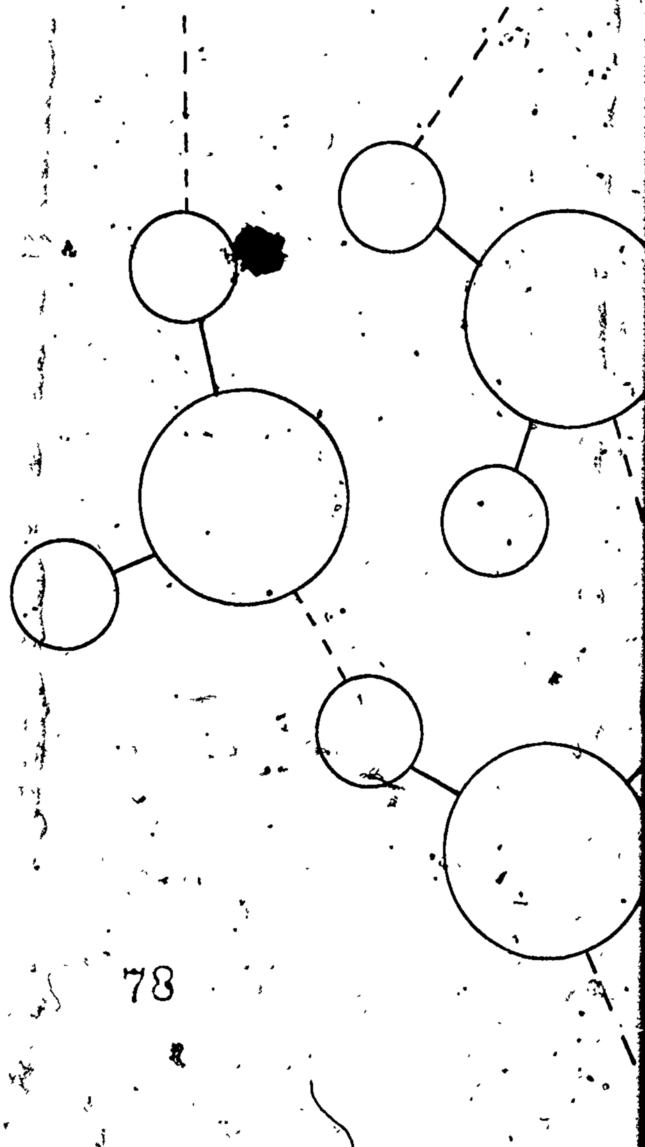
Lakes and streams naturally will attempt to correct the pollution effects. Dilution plays a major role in correction of pollution problems. As the concentration decreases sensitive populations return. Community balance then is restored and the pollutants can be effectively reduced.

TRANSPARANCY LIST

THE WATER MOLECULE

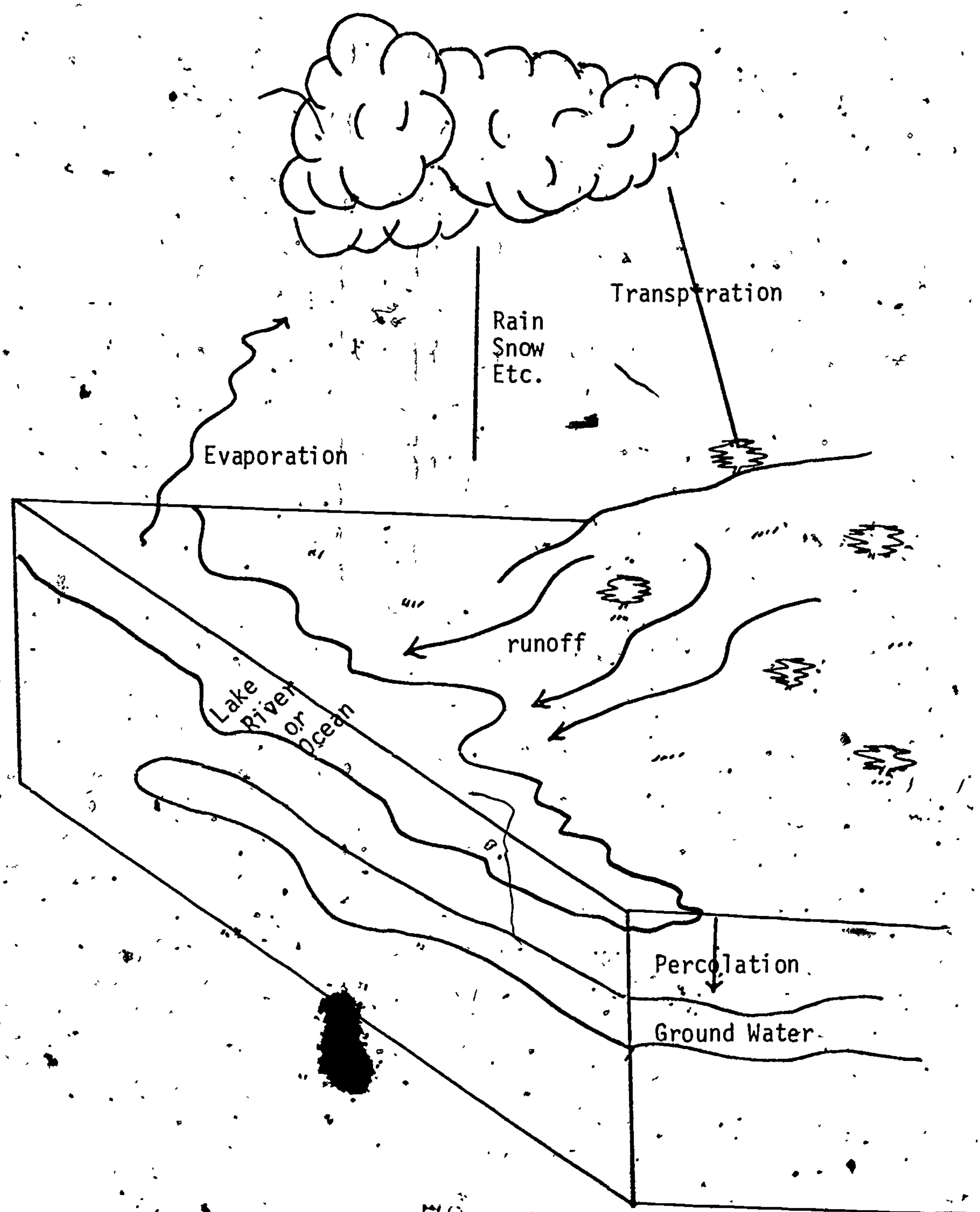


H_2O

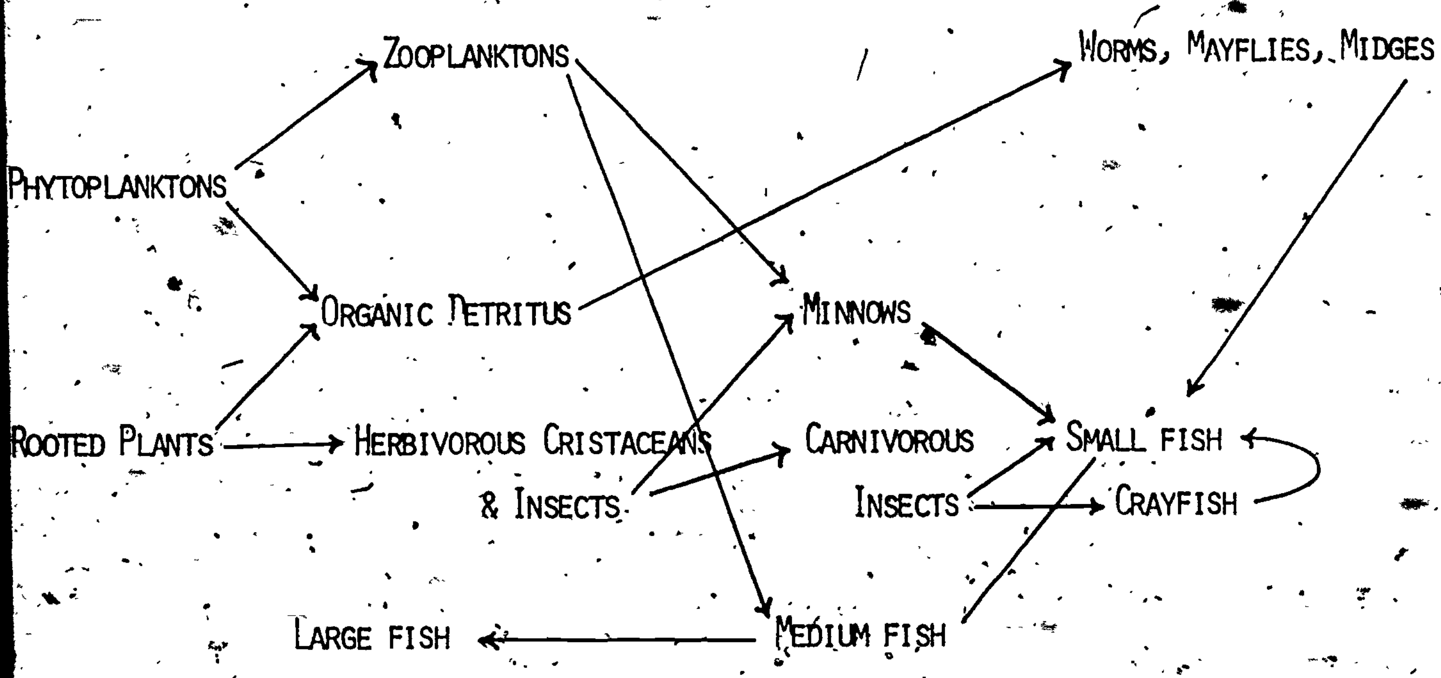


#2.

THE HYDROLOGIC CYCLE

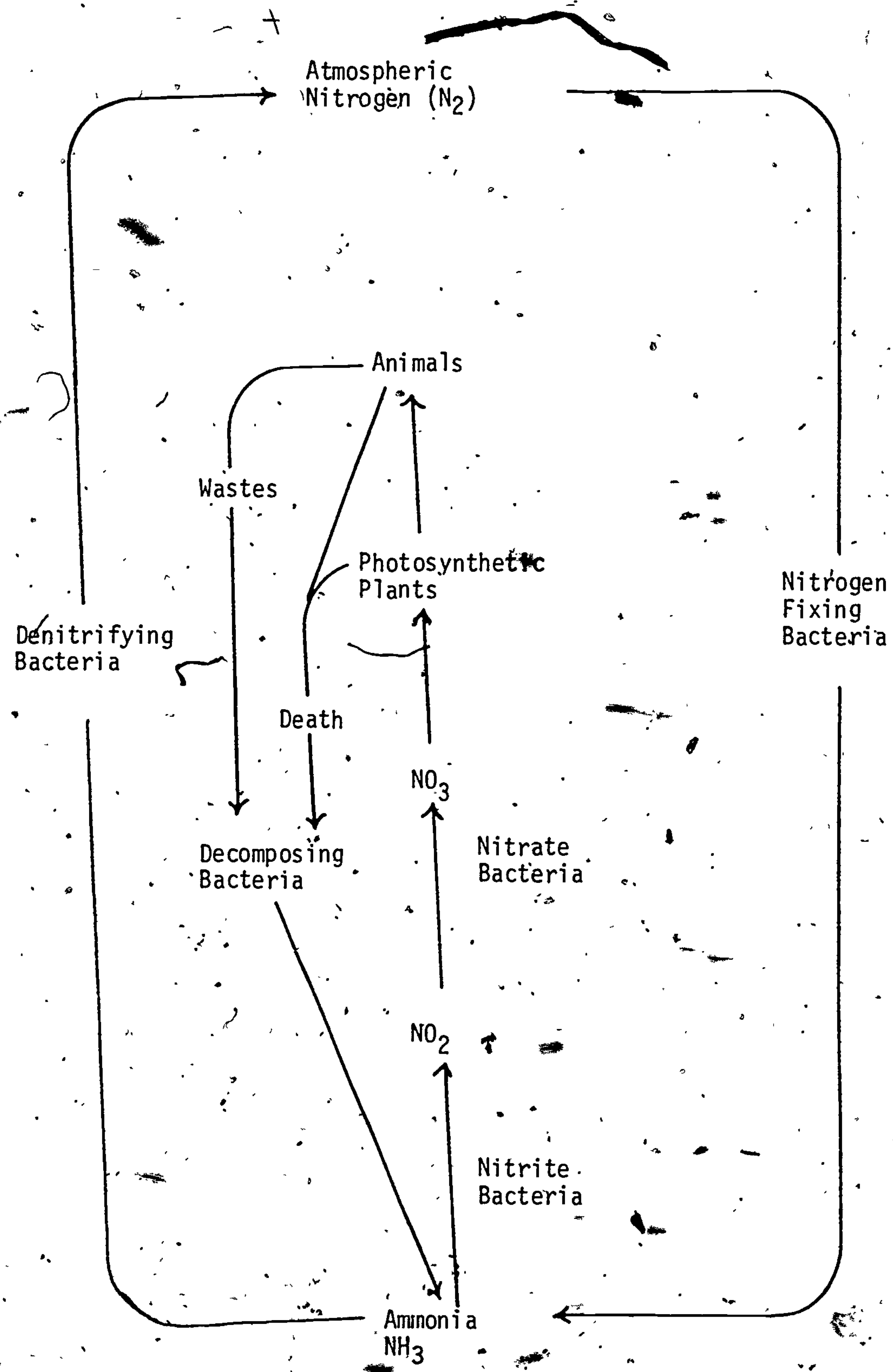


A Food Web in an Aquatic Habitat



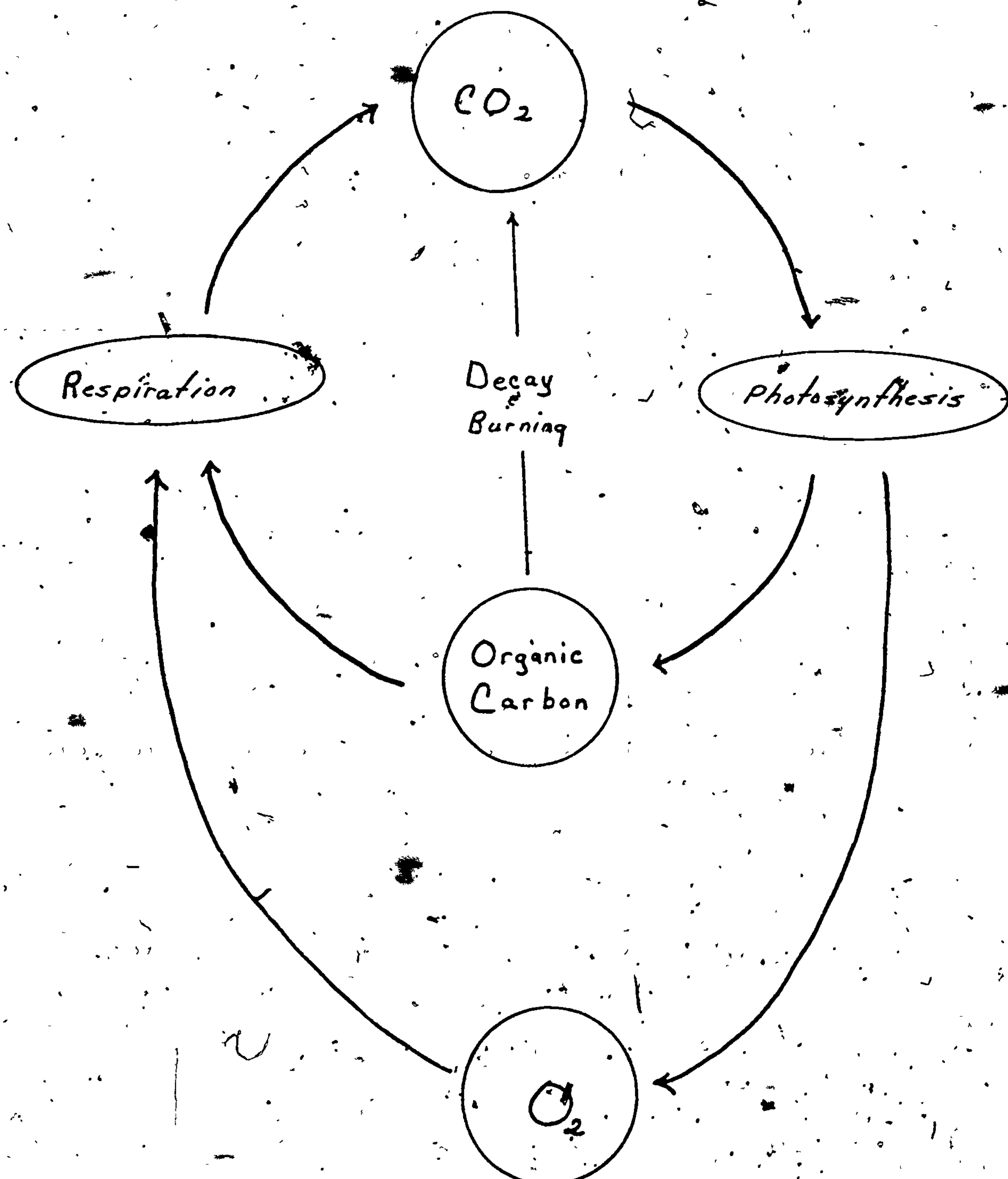
#9

THE NITROGEN CYCLE



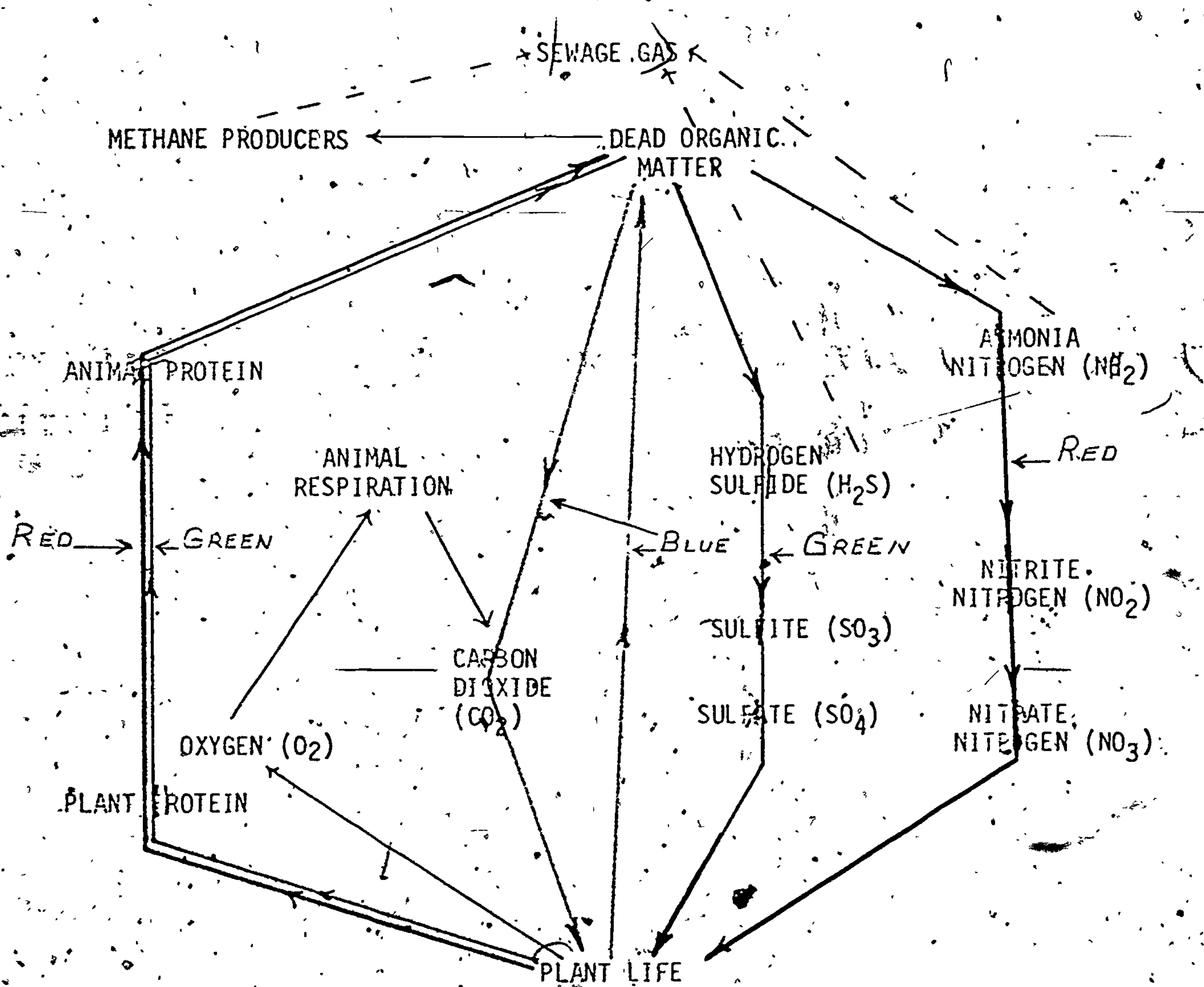
#5

Carbo[illegible] Oxygen Cycles



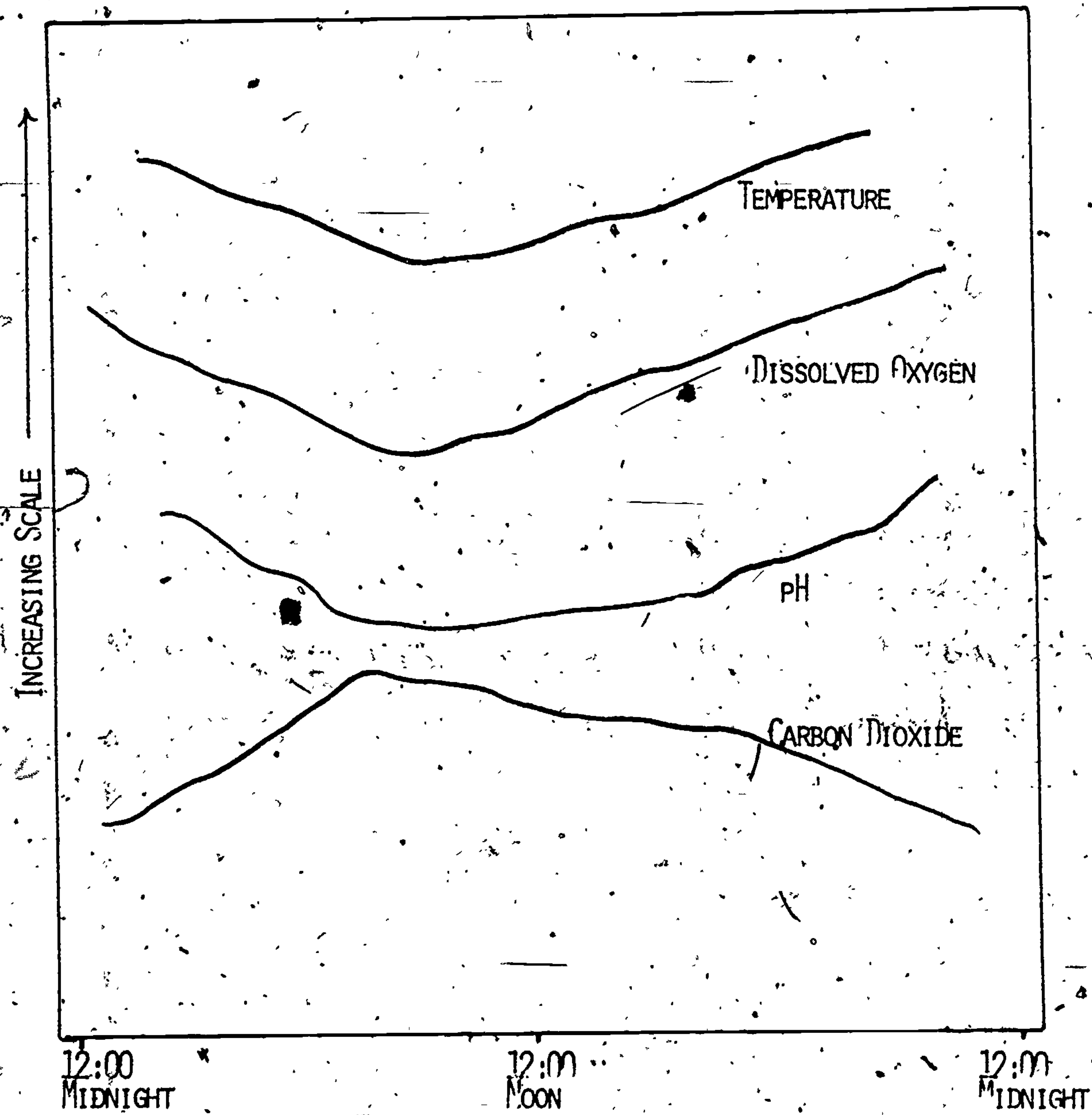
#6

Practice Problem Solution

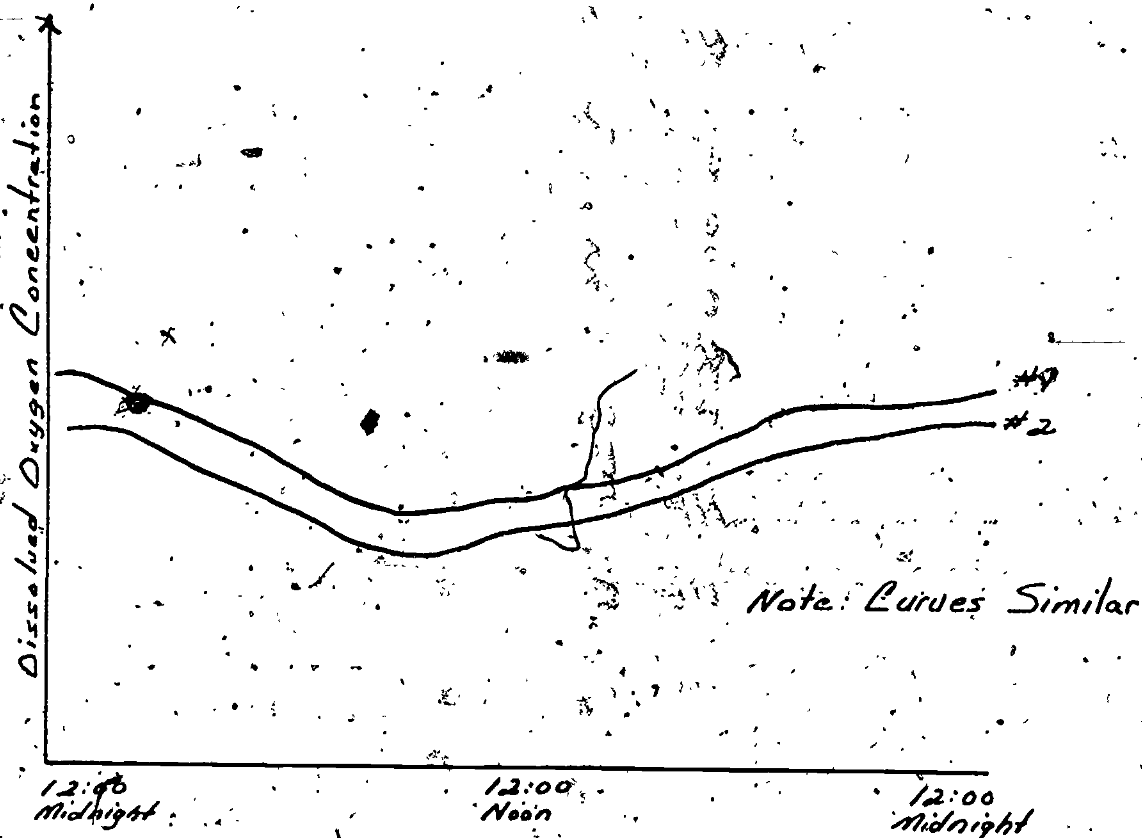


THE NITROGEN, SULFUR, AND CARBON CYCLES OF DECAY

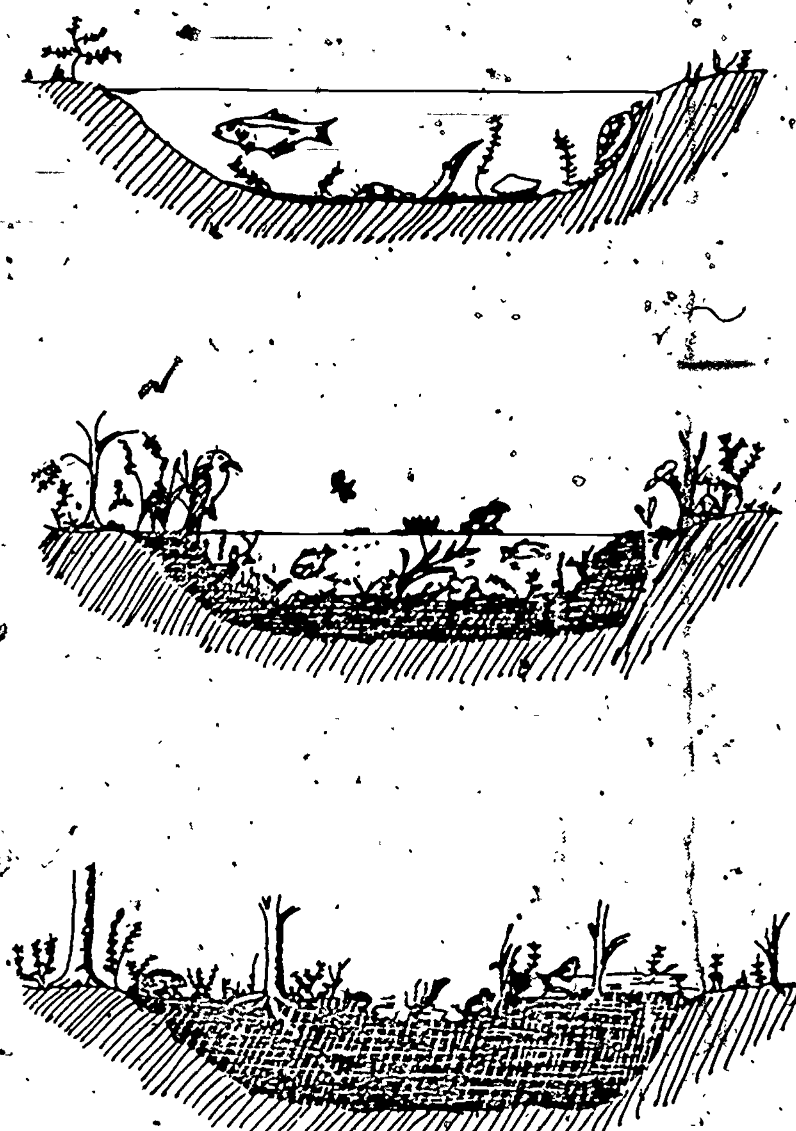
DAILY CYCLES IN NATURAL WATERS



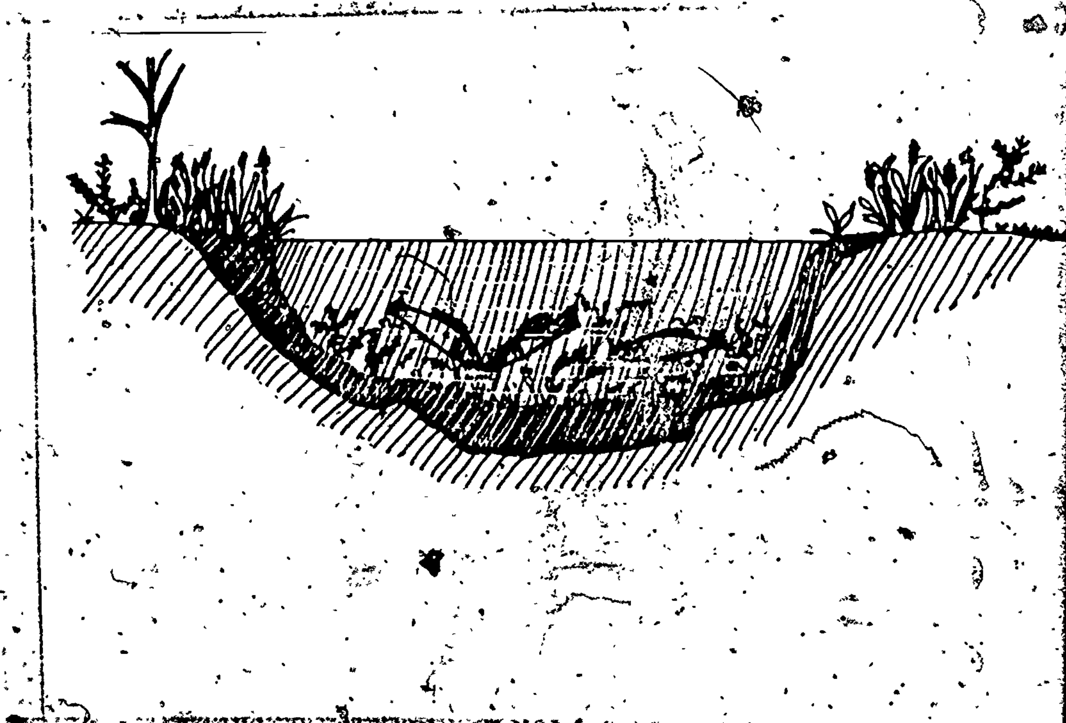
PROBLEM SOLUTION



Succession

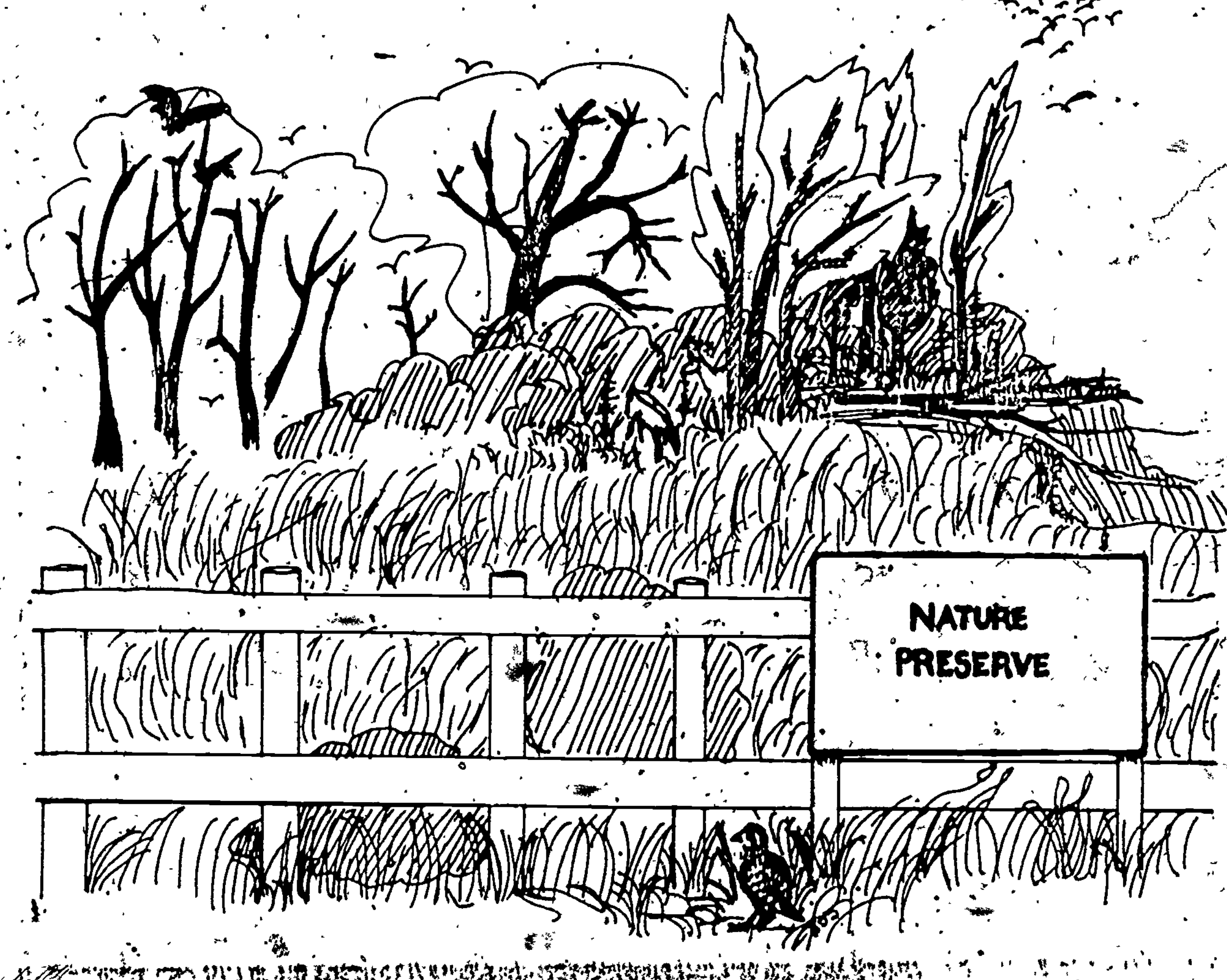


Dominance



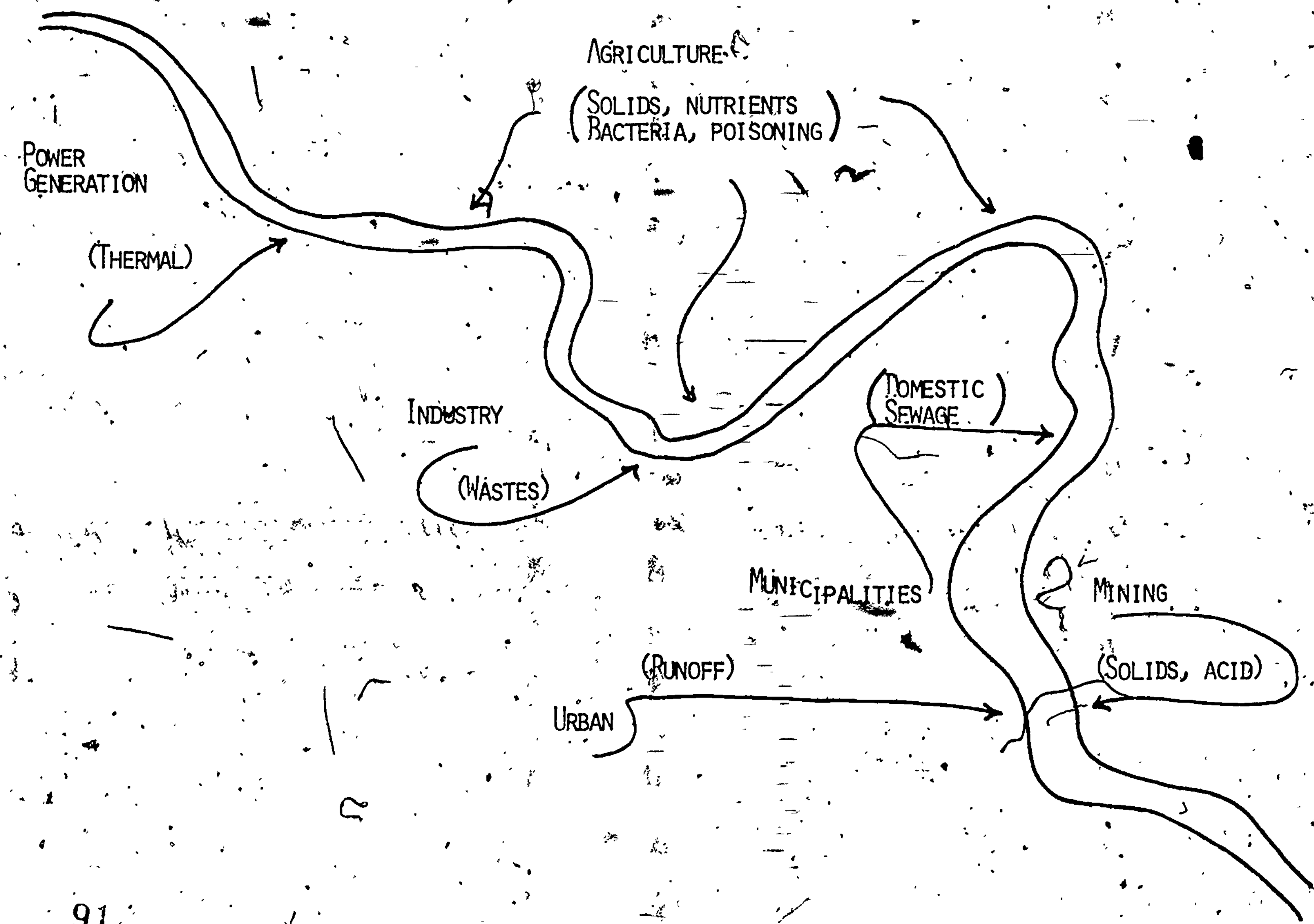
Co-dominance

Man - a Positive Force

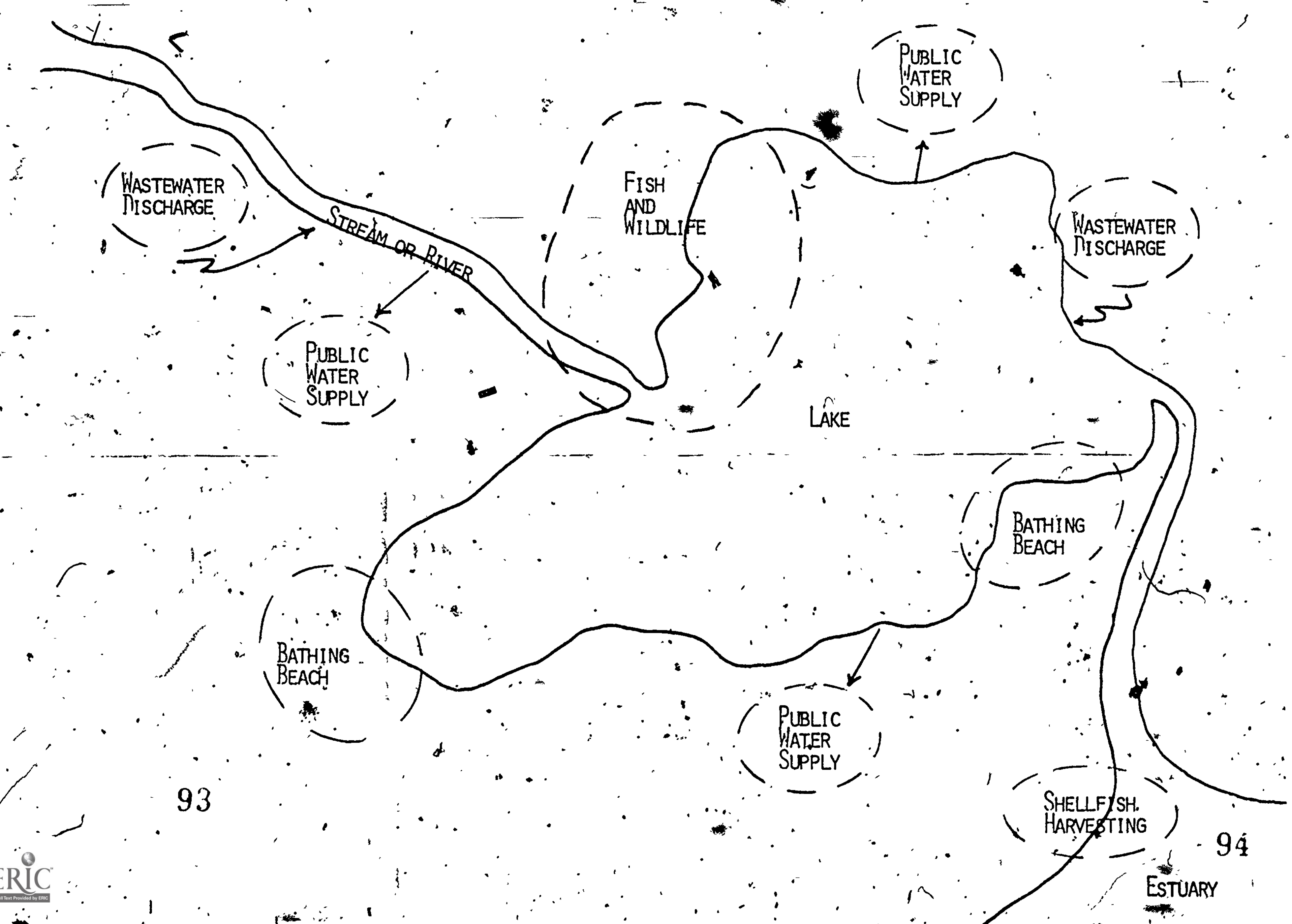


Controlled Disruption

TYPES AND SOURCES OF POLLUTION



WATER REUSE


WASTEWATER DISCHARGE
STREAM OR RIVER
PUBLIC WATER SUPPLY
FISH AND WILDLIFE
PUBLIC WATER SUPPLY
WASTEWATER DISCHARGE
LAKE
BATHING BEACH
BATHING BEACH
PUBLIC WATER SUPPLY
SHELLFISH HARVESTING
ESTUARY

Module No:	Module Title: Natural Systems
	Submodule Title: Primitive States of Nature
Approx. Time: 1/3 hour	EVALUATION - Part A

Objectives:

Upon completion of this module the participant should be able to correctly answer 75% of the following evaluation questions.

Evaluation Questions

Choose the best answer

1. The water molecule is chemically abbreviated

_____a. 2 HO

_____b. HO_2

_____c. H_2O

_____d. H_2O_2

2. As water freezes, its density

_____a. Increases

_____b. Decreases

_____c. Remains unchanged

3. In the nitrogen cycle, denitrifying bacteria

_____a. Convert atmospheric N_2 to NH_3

_____b. Convert NH_3 to atmospheric N_2

_____c. Convert NH_3 to NO_2

_____d. Convert NO_2 to NH_3

4. Green plants give off _____ as a gaseous byproduct of photosynthesis

_____a. Oxygen

_____b. Carbon dioxide

_____c. Carbon monoxide

_____d. Hydrogen

5. Herbivors are animals whose diet consists chiefly or entirely of

_____a. Decaying plants and animals

_____b. Small animals

_____c. Industrial sewage

_____d. Plant matter

6. The hydrologic cycle

_____a. Is the cyclic movement of the earth's saline water supply

_____b. Is the cyclic movement of the earth's fresh water supply

_____c. Is the cyclic movement of the earth's hydrogen supply

7. Which is not a typical food chain progression

_____a. Wheat bull snakes mice

_____b. Plants deer cougar

_____c. Corn mice cats

_____d. Algae plankton fish

8. Which of the following are examples of limiting factors

_____a. Depletion of nutrient supplies

_____b. Accumulation of toxic waste material

_____c. Preditation

_____d. Disease

9. Solar radiation, color, and turbidity of natural waters are interrelated.

_____a. True

_____b. False

10. Natural waters can be defined as: Water as it occurs in its natural state, usually containing other solid, liquid, or gaseous materials in solution or suspension.

_____a. True

_____b. False

11. The annual temperature cycle of a lake takes into consideration which of the following:

_____a. Light absorption

_____b. Heat dynamics

_____c. Density phenomina

_____d. Wind action

12. Dimictic lakes are ones which have a maximum temperature of 4° C.

_____a. True

_____b. False

13. Dissolved oxygen level is generally _____ in an old slow moving stream than a young rapid moving supplies

_____a. The same as

_____b. Higher

_____c. Lower

14. What is the effect on population diversity as a stram ages.

_____a. Population diversity increases

_____b. Population diversity remains constant

_____c. Population diversity continually decreases

_____d. Population diversity increases for a time then begins to decrease as the stream gets old.

15. An artisian aquifer is the same as an unconfined aquifer.

_____a. True

_____b. False

16. A good water bearing formation has high porosity, permeability, and transmissibility.

____a. True

____b. False

Module No:	Topic: EVALUATION - Part A

Instructor Notes:	Instructor Outline:
Answers 1. c 2. b 3. b 4. a 5. d 6. b 7. a 8. a, b, c, d, (all are correct) 9. a 10. a 11. a, b, c, d 12. b 13. c 14. 15. b 16. a	The instructor shall give the participants Evaluation - Part A after completing Natural Systems - Primative States of Nature.

Module No:	Module Title: Natural Systems
	Submodule Title: Aquatic Ecology
Approx. Time: 1/3 hour	EVALUATION - Part B

Objectives:

Upon completion of this module the participants should be able to correctly answer 75% of the evaluation questions.

Evaluation Questions

Choose the best answer

1. High birth rate combined with an extended life span can lead to

____a. Extinction

____b. Overpopulation

____c. Stabilized population

____d. None of the above

2. Communities are formed due to the interdependence of the various populations.

____a. True

____b. False

3. Which of the following terminologies represent some form of interdependence between populations.

____a. Parasitism

____b. Mutalism

____c. Preditation

____d. Mating

4. Communication can take place only within a given population

____a. True

____b. False

5. Succession can transform

_____a. A rocky hillside into a soil capable of supporting trees and shrubs.

_____b. A lake into land capable of supporting trees and shrubs.

_____c. Both a and b

6. Co-dominance of a community can be defined as

_____a. Control of the community's environment by 2 or more populations

_____b. Two of more populations having the same largest numbers

_____c. The 2 largest animals of a community by size.

7. Community succession is a natural process

_____a. True

_____b. False

8. Which of the following environmental changes can upset a succession pattern?

_____a. Dramatic change in flow of a stream

_____b. A fire wiping out a large forest

_____c. Man damming up a river

9. Limiting the food supply of 1 population has the capability of limiting the growth of the entire community.

_____a. True

_____b. False

10. Population diversity

_____a. Creates instability in a community ecosystem

_____b. Adds stability to a community ecosystem

_____c. Has little effect on a community ecosystem

11. Seasonal changes of a community ecosystem is mainly due to changes in temperature and light.

____a. True

____b. False

12. Seasonal changes of a community result in major permanent environmental changes.

____a. True

____b. False

13 - 16 Effect of man

13. Man is always a detrimental force in community ecology.

____a. True

____b. False

14. Man's chief effect on an ecosystem is to

____a. Make it more comples

____b. Ruin it

____c. Simplify it

____d. Introduce stress sensitive plants

15. Cooling towers are used to

____a. Eliminate the need for a stream or lake

____b. Relieve thermal loading of a stream or lake

____c. Control chemical pollution

____d. Eliminate algae growth

Module No:	Topic: EVALUATION - Part B

Instructor Notes:	Instructor Outline:
Answers 1. b 2. a 3. a, b, & c 4. b 5. c 6. a 7. a 8. a, b, & c 9. a 10. b 11. a 12. b 13. b 14. c 15. b	The instructor shall give the participant Evaluation - Part B after completing Natural Systems - Aquatic Ecology.

Module No:	Module Title: Natural Systems
	Submodule Title: Water Pollution
Approx. Time: 1/3 hour	EVALUATION - Part C

Objectives:

Upon completion the participant should be able to correctly answer 75% of the following evaluation questions.

Evaluation Questions

Choose the best answer

1. Pollution can also be termed as:

    ____a. Enhancing the environment

    ____b. Stabilizing the environment

    ____c. Fouling the environment

    ____d. Studying the environment

2. Water pollution is proportional to the development of human society

    ____a. True

    ____b. False

3. Industrial wastes are major contributors of which of the following pollutants

    ____a. Nitrogen and phosphorous compounds

    ____b. Inorganic suspended solids

    ____c. Acids and alkalis

    ____d. Nitrates

    ____e. Heavy metals

    ____f. Pathogenic bacteria

    ____g. Thermal increases

4. Algae blooms are a side effect of

_____a. Nutrient pollution

_____b. Winter

_____c. Inorganic suspended solids pollution

_____d. Sulfate and chloride pollution

5. Winter street runoff is a major source of chloride and sulfate pollution.

_____a. True

_____b. False

6. Match the pollutant type with the primary effect

_____a.	Nitrogen and phosphorous compounds	1.	Fluctuations in pH
_____b.	Inorganic suspended solids	2.	Infant poisoning
_____c.	Heavy metals	3.	Turbidity increase
_____d.	Acids and alkalis	4.	Algae blooms
_____e.	Chlorides and sulfates	5.	Laxative effects
_____f.	Oxygen consuming matter	6.	Depletes oxygen supply
_____g.	Nitrates	7.	Toxic to all humans

7. Turbidity

_____a. Interferes with photosynthesis

_____b. Is unimportant as a pollution effect

_____c. Smothers bottom life activities

_____d. Both a and c

8. Depleted oxygen supply

_____a. Stifles aquatic life

_____b. Stimulates squatic life

_____c. Creates algae blooms

_____d. None of the above

9. Excessive weed growth leads to what 2 of the following effects

_____a. Transmission of disease

_____b. Infant poisoning

_____c. Increased depletion of dissolved oxygen

_____d. Taste and odor production

10. Which of the following can be termed a direct biological pollutant

_____a. Algae blooms

_____b. Pathogenic bacteria

_____c. Decomposing aquatic animals

_____d. Excessive weed growth

11. The best corrective measure for pollution is prevention.

_____a. True

_____b. False

12. Dilution plays only a small part in stream self-purification.

_____a. True

_____b. False

13. Immediately following introduction of organic wastes into a receiving river there is a zone of

_____a. Degradation

_____b. Decomposition

_____c. Recovery

_____d. Cleaner water

14. Oxygen sag is proportional to the amount of organic waste introduced.

_____a. True

_____b. False

15. Water reuse is

_____a. Not necessary

_____b. Is constantly occurring

_____c. Can only be done in rural communities

_____d. Will only begin if the rain stops

Module No:	Topic: EVALUATION - Part C

Instructor Notes:	Instructor Outline:
	The instructor shall give the participants Evaluation - Part C after completing Natural Systems - Water Pollution.

Answers

1. c
2. a
3. a, c, d, e, g
4. a
5. a
6. a - 4
   b - 3
   c - 7
   d - 1
   e - 5
   f - 6
   g - 2
7. d
8. a
9. c & d
10. b
11. a
12. b
13. a
14. a
15. b